



BEHAVIORAL ISSUES ASSOCIATED WITH LONG DURATION SPACE EXPEDITIONS

REVIEW AND ANALYSIS OF ASTRONAUT JOURNALS

ANACAPA SCIENCES, INC.
Santa Barbara, California 93101

“The human factor is three quarters of any expedition.”
– Roald Amundsen

**Behavioral Issues Associated With Long Duration Space Expeditions:
Review and Analysis of Astronaut Journals**

Experiment 01-E104 (Journals)

Final Report

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| 14. ABSTRACT: Personal journals maintained by NASA astronauts during six-month expeditions onboard the International Space Station were analyzed to obtain information concerning a wide range of behavioral and human factors issues. Astronauts wrote most about their work, followed by outside communications (with mission control, family, and friends), adjustment to the conditions, interactions with crew mates, recreation/leisure, equipment (installation, maintenance), events (launches, docking, hurricanes, etc.), organization/management, sleep, and food. The study found evidence of a decline in morale during the third quarters of the missions and identified key factors that contribute to sustained adjustment and optimal performance during long-duration space expeditions. Astronauts reported that they benefited personally from writing in their journals because it helped maintain perspective on their work and relations with others. Responses to questions asked before, during, and after the expeditions show that living and working onboard the ISS is not as difficult as the astronauts anticipate before starting their six-month tours of duty. Recommendations include application of study results and continuation of the experiment to obtain additional data as crew size increases and operations evolve. | | | | | |
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Dr. Claude Bachelard writing in his journal during the International Biomedical Expedition to the Antarctic (IBEA), in 1981; the electrodes on his face and chin are for monitoring EEG and EMG. From, Rivolier, J., Goldsmith, R., Lugg, D.J., and Taylor, A.J.W. *Man in the Antarctic: The Scientific Work of the International Biomedical Expedition to the Antarctic (IBEA)*, Taylor & Francis: London, 1988.

EXECUTIVE SUMMARY

This report describes a content analysis of personal journals that were maintained for this purpose by NASA astronauts during expeditions onboard the International Space Station (ISS). Using methods developed during previous analogue research, the study provides the first quantitative data on which to base a rank-ordering of the behavioral issues associated with long-duration space operations.

The first level of analysis identified the relative salience of 24 major categories of issues with behavioral implications, among which the top 10 categories account for 88 percent of all journal entries: Work, Outside Communications, Adjustment, Group Interaction, Recreation/Leisure, Equipment, Events, Organization/Management, Sleep, and Food. The second-level of analysis identified 108 subcategories within the major categories and calculated their relative frequencies and temporal distributions. The third level of analysis focused on the tone of entries as an indicator of specific problems and general morale, using a metric defined as Net Positivity/Negativity (NPN); results of the NPN analysis support hypotheses concerning a third quarter phenomenon, which also is explained in the report. Responses to questions asked before, during, and after the expeditions suggest that living and working onboard the ISS is not as difficult as the astronauts anticipate before starting their six-month tours of duty. Astronauts reported that they benefited personally from writing in their journals and recommended continuation of the research.

Examples of journal entries and graphic representations of data are used to illustrate the quantitative analyses. Together, the entries and analyses provide a comprehensive description of ISS operations from the crew perspective. Example entries included in the report concern activities, events, and observations and reflect the normal ups and downs of daily life onboard an orbital space station. It is important to note that no single journal entry, nor even a subset of entries, accurately describes an entire expedition, but rather, the most salient issue at the time the entries were written. The results show that NASA's efforts concerning interpersonal issues, teamwork, psychological support, and leadership have been particularly effective. Operational implications of study results are summarized and then presented in the form of specific recommendations to facilitate living and working in space, whether onboard the ISS, a spacecraft bound for an asteroid, or an interplanetary ship.

“Truly, the whole secret lies in arranging things sensibly,
and especially in being careful about the food.”
- Fridtjof Nansen

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Subjects in a study of isolation and confinement prepare to enter their spacecraft simulator for a 12-day experiment in 1961. See Appendix A for more information.

INTRODUCTION

This report describes research conducted under Cooperative Agreement NCC9-171 for the Behavioral Health and Performance Office at NASA's Johnson Space Center. The study described in this report is based on the premise that the introspective accounts of individuals who are living and working in stressful or unusual environments can provide useful information about the factors that affect individual and group performance under those conditions. The study uses methods developed during space analogue research to systematically analyze the content of confidential journals that were maintained for this purpose by crew personnel during expeditions to the International Space Station (ISS). The report is presented in four sections. This introduction describes why the study was conducted and provides background information and the historical context of the research. The introduction is followed by a description of the research tasks performed to collect and analyze the data and, in turn, is followed by a section devoted to study results. The report concludes with a discussion of operational implications and recommendations based on those results.

BACKGROUND

Since the beginning of human space flight, mission planners have asked flight surgeons, psychologists, and psychiatrists for quantitative data concerning the relative importance of the behavioral issues that must be considered when planning operations and designing equipment and habitats for long duration space expeditions. The response always has been that interpersonal relations among crew members is the most important issue, a belief shared by many science fiction writers, the general public, and most important, astronauts. However, physicians and behavioral scientists could not justify the primacy of "getting along with each other" empirically, nor provide a systematic method for calculating how much more or less important any issue is than another. Planners and equipment designers are data-driven and need a metric to guide the allocation of scarce resources, but laboratory and space analogue studies usually focus on a specific issue (e.g., sleep, communications), which makes it impossible to place the various influences on human behavior in order of importance to space crews.¹

A previous content analysis of journals that were written during expeditions on Earth provided the first quantitative data on which to base a rank-ordering of behavioral issues in terms of salience, or importance.² That study identified 22 major categories of behavioral issues associated with living and working in isolation and confinement and placed the categories and constituent themes in order of priority based on the relative frequency of category assignments. The information derived from this and other space analogue studies has been instructive. However, research opportunities on the ISS have made it possible to study the issues under operational conditions with the participation of space crews. The flight experiment documented in this report was the logical next step beyond analogue studies and addresses the behavioral and human factors questions of highest priority in NASA's Critical Path Roadmap, risk assessments, and mitigations.

OBJECTIVE

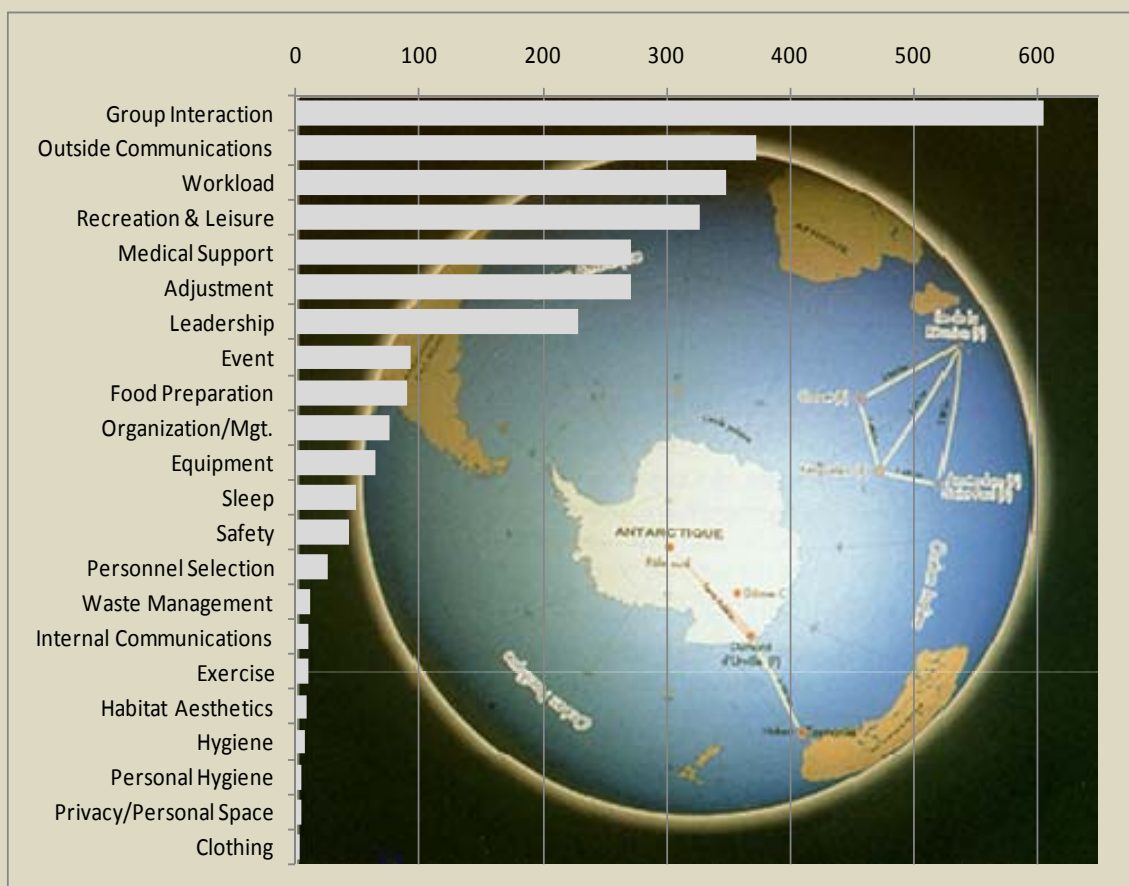
The objective of this study has been to identify the relevant behavioral factors and obtain data to inform decisions concerning the priorities that should be placed on the various behavioral issues to prepare for and manage future space expeditions. Study results can be applied to improve selection, training, support, scheduling, and the design of equipment and procedures.

¹ For more information about space analogue research see, Suedfeld, P., and Steel, G.D. The environmental psychology of capsule habitats. *Annual Review of Psychology*, 51, 227-253, 2000.

² The project was a collaboration among NASA's Division of Life Sciences, the French Space Agency (CNES), Territoire des Terres Australes et Antarctiques Françaises (TAAF), and Institut Français Pour La Recherche Et La Technologie Polaires (IFRTP).

THE "FRENCH DIARIES STUDY"

A content analysis was performed of nine personal journals that were maintained for this purpose by the leaders and physicians at the Dumont d'Urville Antarctic facility and three French research stations located on small islands in the South Indian Ocean; the "diaries" were written during a 13-month period in 1993-1994 as part of the International Antarctic Psychological Program (IAPP). The investigators assigned all diary entries to a primary category and more than half of the entries also were assigned to a secondary category, based on similarity of content. "Group Interaction" was found to be the most frequently-assigned of the 22 categories to emerge from the analysis, as illustrated in the following figure. Themes (clusters of entries on similar topics) also were identified from the diary entries within each category of behavioral issues.³



All entries were coded as positive, negative, or neutral in tone, to permit analyses using a metric defined as net positivity-negativity, which was derived by dividing each journal into chronological quarters and then subtracting the proportion of negative entries from the proportion of positive entries within each segment. The analysis of Net Positivity/Negativity found evidence of a decline in morale during the third quarter, regardless of mission duration or location. Some study results were contrary to the expectations of experts. For example, shorter missions (69 to 180 days) generated greater negativity than the longer missions (230 to 363 days) and diaries from the insular stations, where visitors disrupt the routine, were more negative than diaries from the isolated and austere Antarctic base. More than 100 specific themes were identified among the 22 categories of issues.

³ Stuster, J., Bachelard, C. and Suedfeld, P. The Relative Importance of Behavioral Issues During Long-Duration I.C.E. Missions. *Aviation, Space, and Environmental Medicine* (71) 9, 2000 (September).
 Stuster, J., Bachelard, C. and Suedfeld, P. *In the Wake of the Astrolabe: Review and Analysis of Diaries Maintained by the Leaders and Physicians at French Remote Duty Stations*. Technical Report to the National Aeronautics and Space Administration, 1999 (February). <http://www.anacapasciences.com/publications/Astrolabe.pdf>

THE RESEARCH

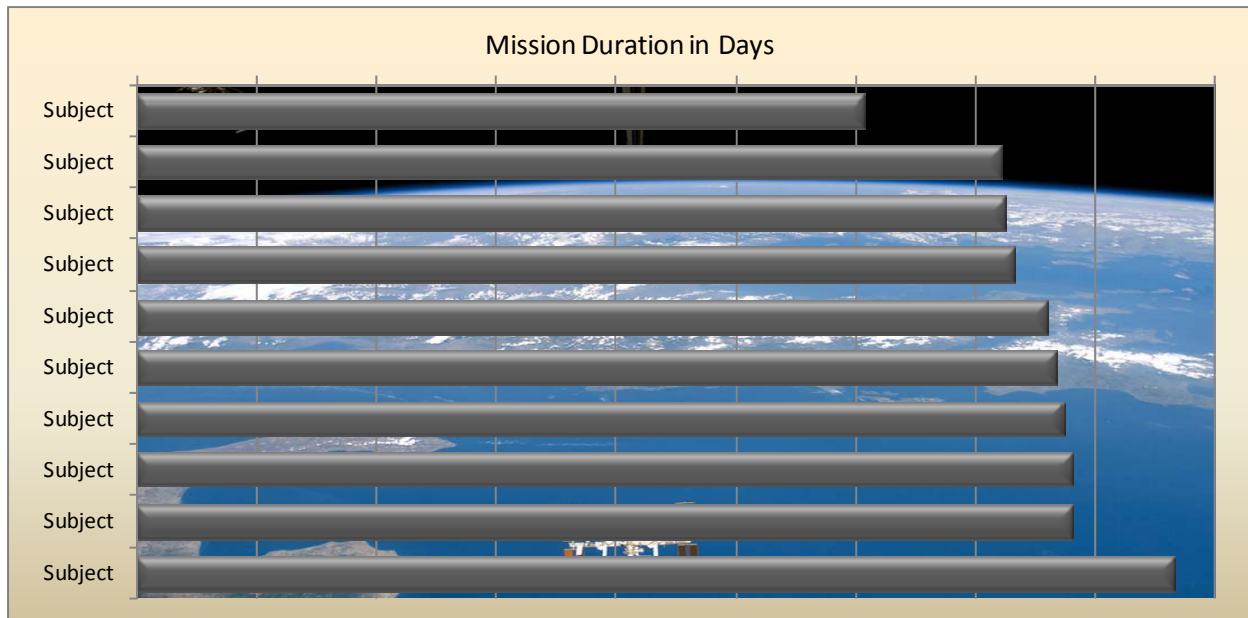
Calculating the number of cases, observations, or subjects required for an experiment to have meaningful results is a concern of all scientists and usually involves a compromise between the ideal research design and what is practical to achieve. For example, public opinion surveys are administered to samples of at least 2,000 carefully-selected individuals in order to obtain sufficient confidence that results accurately reflect the beliefs of a larger segment of the population. In contrast, the designers of more intrusive experiments, such as those requiring painful muscle biopsies, are content with as few as five subjects. The current study was confronted with an unusual variation of the sample size dilemma: How many subjects would be necessary to produce meaningful results if the subjects were to participate one at a time for periods of approximately six months each? The inclination to maximize statistical power with a large sample was tempered by the recognition that the ideal study could take so long to complete that it would be both too expensive and too late to be of use to the sponsoring agency. Many medical and physiological experiments rely on only ten subjects, so ten was the number specified by the PI during the planning phase of the experiment. It would take a minimum of five years to obtain the criterion number of subjects—longer if any astronauts declined the invitation to participate in the study or agreed to participate and then did not produce an acceptable journal.

Ten subjects normally would be considered insufficient for statistical analysis in studies of human behavior. However, in the current project each subject generated an exceptionally large volume of data in the form of multiple journal entries during a prolonged period under operational conditions. The large volume of data per subject more than compensates for the relatively small sample if it can be assumed that the astronauts who participated in the study accurately represent the population from which the crews of future space missions would be selected. The ten participants do, in fact, reflect the composition of the Expedition Corps, the cadre of astronauts preparing for long duration tours of duty onboard the ISS and beyond; the sample includes men and women; scientists, engineers and pilots; and civilian and military personnel.

The study is based on the assumption that the more a person writes about a topic in a journal or diary, the more important that topic is to the person at that time. It is a reasonable assumption, but maintaining a continuous written record for a period of six months requires sustained commitments of time and effort. Participants were asked to make journal entries at least three times per week while on the ISS using a laptop computer and MSWord template that automatically inserted the date on a new page each time the file was opened; sessions usually were hard scheduled (i.e., appeared on the daily timeline), but moved to the optional task list during periods of high-tempo activity. Participants were encouraged to address whatever topics were most salient to them and to write candidly about their experiences and observations, but they were cautioned to avoid focusing exclusively on negative issues. Crews were assured during Informed Consent Briefings (ICBs) that no one other than the astronaut and principal investigator would have access to the original journals and that all identifying information would be removed from any excerpts or examples used in reports, articles, or presentations. The journals were protected by passwords and encrypted during downlink and transfer to the investigator, a process that was performed monthly according to a formal protocol designed to further ensure the security of the data. The encrypted files were deleted from the NASA server immediately after the transfers were completed, usually within 15 minutes of the downlink.

The durations covered by the ten journals obtained during the study ranged from approximately 150 to more than 200 days, with an average of 187.7 days on board the ISS; all but one of the journals spanned a period of at least six months, as illustrated in the following figure.⁴

⁴ Random numbers have been assigned to replace subjects' names and the orders of the expeditions have been altered in all figures to prevent the identification of individual participants in the study.



CODING THE DATA

The investigator read all journals in increments following each monthly downlink. Each journal was read again following completion of the expedition and converted to a database format using a spreadsheet configured for this purpose. Journals were divided automatically into chronological “sessions” by the date that was inserted each time a journal was opened. Coding began by parsing journal text into segments concerning a topic and then entering the text in the appropriate cells of the spreadsheet; these segments, called “entries” in this report, ranged in length from a single sentence to a complete paragraph. All entries were assigned to a primary topical category and most also were assigned to a secondary category; about half of the entries also were coded for a third category, a departure from the method followed in the previous analogue study, intended to provide a comprehensive accounting of topics mentioned in the journals. Two categories emerged almost immediately during the coding process that were not among the 22 identified during the previous study; Logistics/Storage and Procedures/Rituals were added to the list for a total of 24 major categories. Sub-categories (clusters of entries on similar topics) later were identified from the diary entries within each major category of issues. The process is described below using two examples; the results of this and other analyses are presented in the following section of the report.

Major Category: Logistics/Storage > Subcategory: Resupply

We’ve been unpacking the Progress. Found our personal items; the US food is once again stocked and we enjoyed some fresh fruit. The first thing I did was eat a grapefruit and it was very good.

Major Category: Food > Subcategory: Food Supply

Z flew into the Lab and tossed me a fresh apple soon after the Progress arrived. That was really great! It was a welcome change.

The first example was assigned to Logistics/Storage as the primary category because the sentence began with a reference to unpacking and then mentioned the resupply of food. In contrast, the second example began with a reference to the apple and then to the recent arrival of supplies. Primary category assignments were made on the basis of order of reference for all coding decisions that involved overlapping behavioral issues (e.g., Outside Communications vs. Organization & Management). The subcategory analysis focused on primary category assignments exclusively to avoid counting entries more than once. The semantic rule was applied systematically, but in many cases the distinction seems to be overly precise. It might be instructive to eventually analyze data sets composed of entries from different major categories, but similar sub-categories (e.g., Resupply and Food Supply).

Entries also were coded as positive, negative, or neutral in tone, to permit analyses using the Net Positivity/Negativity metric suggested by Peter Suedfeld during the French Diaries Study. That is, each journal was divided into chronological quarters and then the proportions of positive, negative and neutral entries were calculated by quarter; the proportion of negative entries was subtracted from the proportion of positive entries to derive the single metric, NPN. Proportions were used in these calculations, rather than actual numbers, to control for differential journal activity among the participants. The entries and associated data were entered into spreadsheets with each row, or record, composed of the following fields.

Subject Number (Coded)

Role (C for commander, FE for flight engineer, SO for science officer)

Mission Day (1 – 200+)

Category 1 (The primary category of behavioral issues to which the entry was assigned)

Category 2 (The secondary category of behavioral issues to which the entry was assigned)

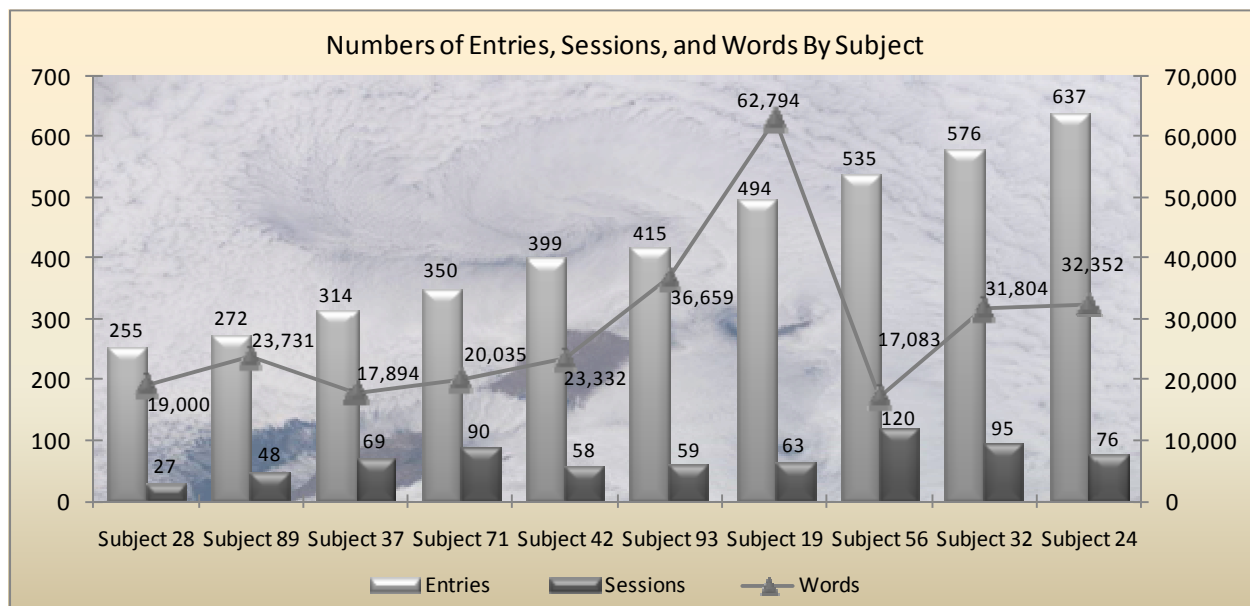
Category 3 (The tertiary category of behavioral issues to which the entry was assigned)

Page (The page number of the original journal on which the entry can be found)

Tone (Whether the entry is positive, negative, or neutral in tone)

Entry (Text of the journal entry)

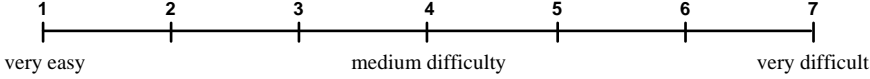
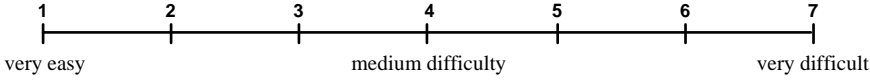
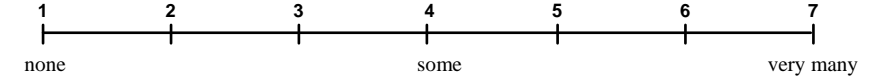
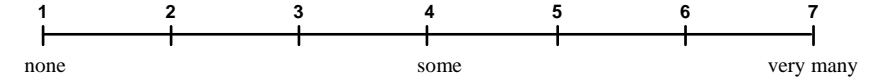
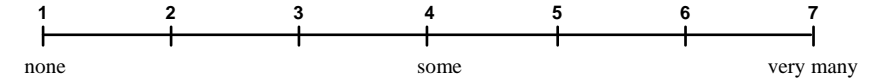
Nearly all of the participants exceeded the minimum commitments, writing more frequently and candidly than expected and producing detailed, personal accounts of life onboard an orbital space station. The 10 participating astronauts devoted a total of 705 sessions to the Journals Experiment and produced 4,247 separate entries composed of nearly 285,000 words—the equivalent of a 1,100-page book. The following figure illustrates the contributions of the astronauts to the numbers of sessions, entries, and words comprised by the Journals database.⁵



QUESTIONNAIRES

In addition to the journal entries, participants completed brief questionnaires prior to launch, at the mid-point of their expedition, and following their return to Earth. Five of the seven questions are reproduced below as they appeared on the pre-launch questionnaires.

⁵ At a minimum of 15 minutes per session, the crew time devoted to the journals exceeded 176 hours, which is believed to be more than any other experiment conducted in space. Most of the astronauts spent far more time maintaining their journals than the minimum commitment.

- A. How PHYSICALLY difficult do you expect this expedition will be?
- 
- B. How MENTALLY difficult do you expect this expedition will be?
- 
- C. Do you expect that there will be EQUIPMENT problems?
- 
- D. Do you expect that there will be ORGANIZATIONAL problems?
- 
- E. Do you expect that there will be INTER-PERSONAL problems?
- 

The two open-ended questions asked,

What do you anticipate will be the most *difficult* aspect of your job during the expedition? And,

What do you anticipate will be the most *enjoyable* aspect of your job during the expedition?

Mid-expedition and post-landing questionnaires asked the same questions, but in the past tense (interrogative). For example, the five questions requesting responses on Likert scales and the two open-ended questions were phrased in the following manner.

How PHYSICALLY difficult has your work been?

What was the most *enjoyable* aspect of your job during the first half of the expedition?

INTER-RATER RELIABILITY

The investigator prepared a sample of the coded journals for inter-rater reliability testing by replacing all names in the text with random initials and all references to shuttle, Progress, and Soyuz missions with the letter “X” or the word “blank”; references to other events (such as hurricanes and elections), certain equipment, and major tasks also were masked to prevent the possibility of attribution to a specific expedition. The “sanitized” sample was sent to Professor Peter Suedfeld for independent coding and analysis.⁶ The results are presented here, rather than in the following section, because the procedure influenced coding. That is, the first sample received reliability scores in the range of 68 to 80 percent, which were accompanied by detailed annotations concerning each coding disagreement. This information led the PI to identify several coding errors in the sample (e.g., entering E for Event instead of EQ for Equipment) and a few inconsistently applied rules, which prompted a review of all ten journals. Corrections and changes based on adjustments to the assignment criteria were made to the database and then an additional sample was prepared for analysis. That sample received reliability scores of 94 percent for tone and 89 percent for category, both of which are within the acceptable range for content analysis. Further adjustments to the coding rules were applied to the entire database to increase reliability prior to data analysis and additional errors were detected and corrected during subsequent analytical tasks. The effects of those improvements to reliability have not been estimated.

⁶ Peter Suedfeld is Professor Emeritus at the University of British Columbia, Past President of the Canadian Psychological Association, and foremost expert on the content analysis of spoken, transcribed, and written text. Dr. Suedfeld also happens to be the leading authority on the effects of isolation and confinement on human behavior.

OTHER POTENTIAL THREATS TO THE VALIDITY OF STUDY RESULTS

Additional potential threats to the internal validity of the study might include variance among the participants in journal activity, volume, net-positivity/negativity, or candor. The previous figure showed the distributions of journal sessions, words, and entries for the ten study participants: sessions ranged from 27 to 120; words from 17,083 to 62,794; and entries from 255 to 637. The number of sessions had the greatest variance, with participants' contributing between 3.8 and 17 percent of the 705 sessions recorded in the journals. The numbers of words written by the astronauts also varied considerably, representing between 6 and 22 percent of the total volume. No correlation is evident in the relationship between the numbers of sessions and the numbers of words written; for example, the most prolific participant wrote more than twice the average number of words, but ranked sixth in the number of sessions, and the astronaut with the most sessions wrote the fewest words. The lowest variance was found in the numbers of entries derived from the ten journals, with individuals contributing between 6 and 15 percent of the 4,247 entries contained in the database (i.e., separately-coded statements about an issue, event, or observation). The data show that some participants wrote more frequently than others; some used more words per entry; and some addressed more issues and events in their journals, but the range for the third variable was less than for the other two.

Entries are the primary units of the content analysis as they are the data that are categorized and counted and from which all study results are derived. It is reasonable to question whether differences in the numbers of entries extracted from the journals might enable individual participants to dominate the analysis and thereby distort results. It was to control this variable that frequencies of category assignments were converted to percentages within each journal (calculated by quarter) to equalize the contributions of all participants to the temporal and overall analyses of NPN. The effects of this procedure were to normalize the data and allow meaningful comparisons among the participants. However, the tallies of entries on which the category and subcategory analyses are based involved combining data from all journals and, for this reason, the process reflects the differential production of the participants. This approach is consistent with the fundamental premise of the method, which assumes that the frequency a topic is mentioned in a journal is a measure of the topic's salience to the author. If a procedure were to be performed that equalized the contributions of the participants to the category and subcategory analyses, it would diminish the study's sensitivity to differences in the astronauts' experiences on the ISS. Concern about this potential threat to validity is further obviated by the near absence of variance in the categories of issues the astronauts considered to be important; for example, the same four categories (Work, Outside Communication, Adjustment, and Group Interaction) appear in the top five of all ten study participants, and in the top four categories of the astronauts who generated the fewest and the most entries. The overall rank-ordering of categories represents the combined values of all ten participants.

Candor is the least quantifiable of the process variables and is most appropriately assessed in binary terms, that is, astronauts were either candid or they were not. It is impossible to determine if the participants wrote candidly in their journals at all times, but it is sufficient to report that all ten journals included entries concerning personal matters and all were peppered with statements that the authors would not want to be attributed. The participants' willingness to write candidly about their experiences contributed to the utility and validity of study results. I have done my best to ensure the anonymity of their contributions.

Because of the large number of behavioral categories, the relatively small number of study participants, and individual differences among them, it was judged to be inappropriate to subject the data to inferential tests of significance.

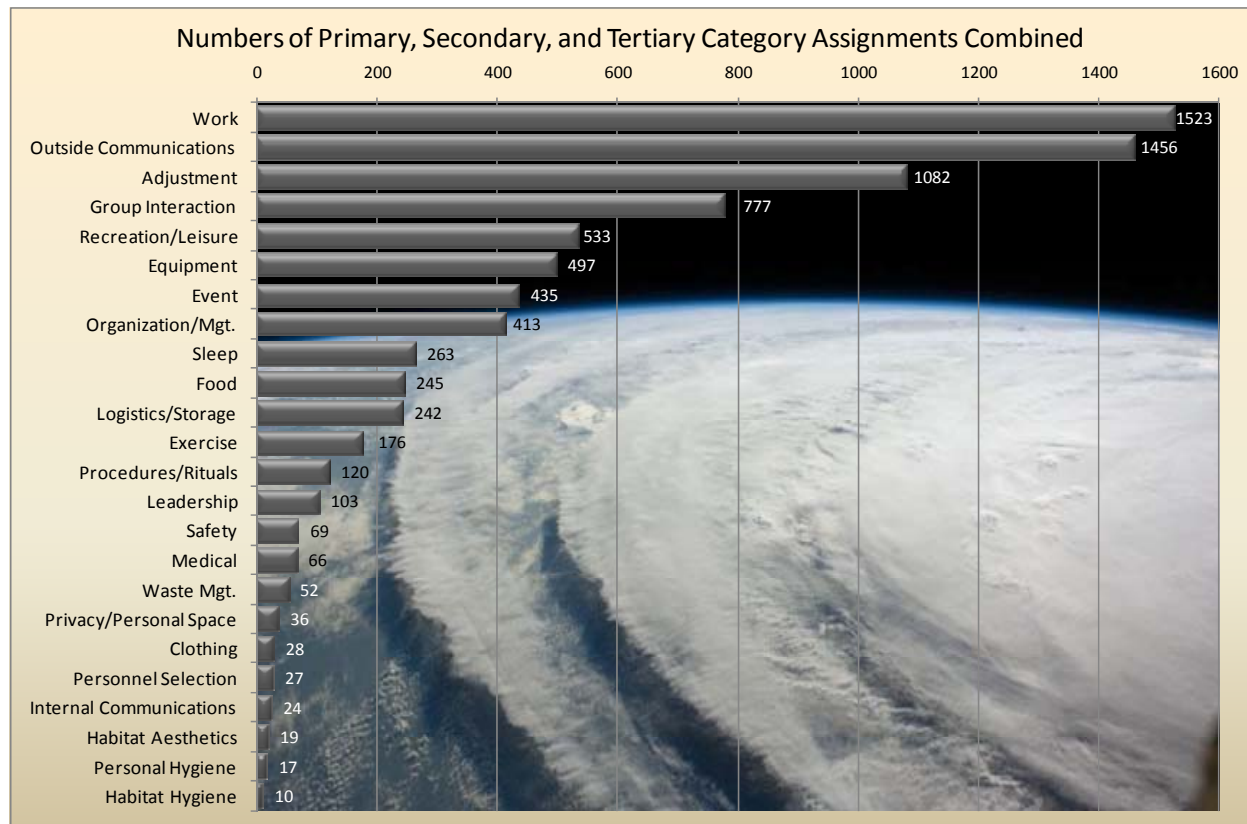
RESULTS

Study results are presented in sections addressing the analyses of major categories of behavioral issues; sub-categories, or themes, within the major categories; Net Positivity/Negativity; and the pre-, mid-, and post-expedition questionnaires.

CATEGORY ANALYSIS

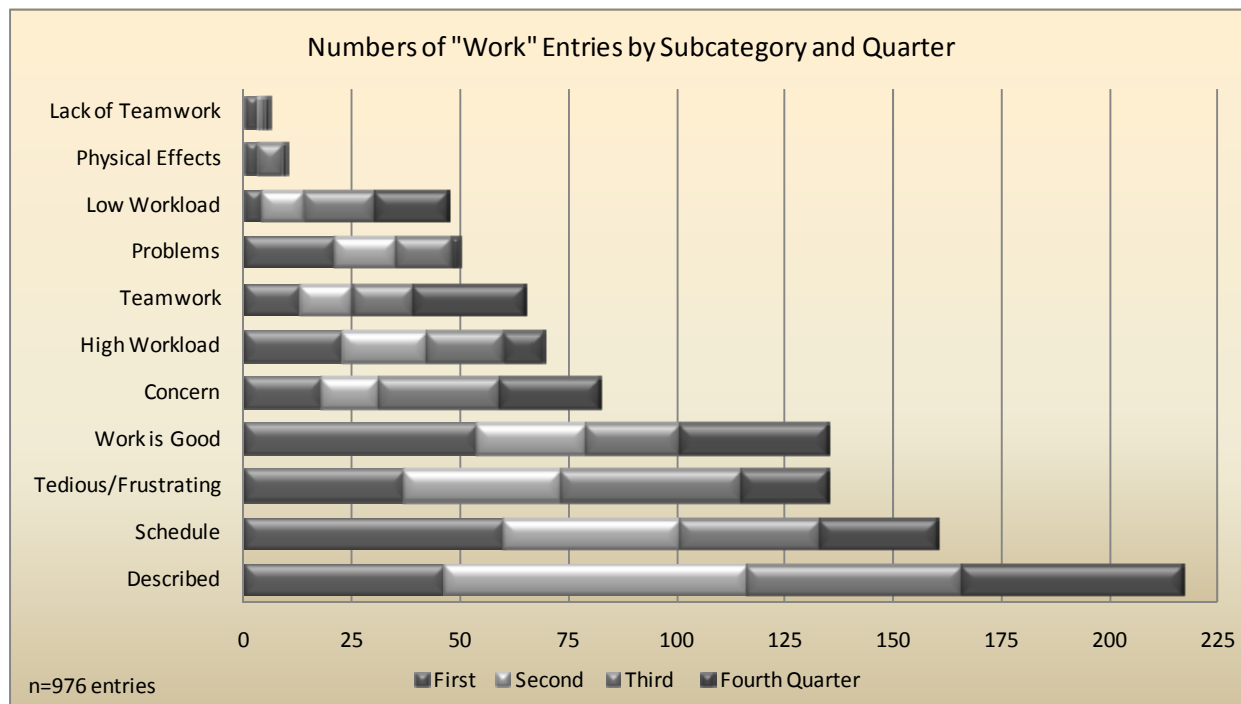
The numbers of journal entries assigned to the 24 major topical categories were tabulated for each journal and then combined to calculate the overall total for each category. The results of that procedure are presented in the following figure, which lists the categories in descending order of frequency. Notable differences between the astronaut journals and the French diaries from the previous study include the astronauts' relatively greater emphasis on work (ranked first vs. third in the French diaries), group interaction (ranked fourth vs. first), adjustment to the conditions (ranked third vs. sixth), equipment (ranked sixth vs. eleventh), leadership (ranked fourteenth vs. seventh), and medical issues (ranked sixteenth vs. fifth). The astronauts' greater emphasis on work and equipment reflects the highly-scheduled, often technical tasks performed by ISS crew; the greater frequency of entries concerning leadership and medical issues in the French diaries probably is related to the authors' roles, which were as leaders and physicians at remote research stations.

Explanations for two of the differences are more speculative. Fewer entries assigned to the group interaction category among the astronaut journals might reflect obstacles to interpersonal relations caused by language differences, a factor that was not present at the French research stations. Also, astronauts and cosmonauts spend much of their time working independently of each other in different modules of the station, and the near absence of conflict reported in the journals reflects astronauts' training and sincere motivation to avoid interpersonal problems. The astronauts probably wrote more about adjusting to their conditions than the previous diarists because their isolation and confinement was greater and only one of the novel aspects to which they must adapt onboard the ISS. Nearly all of the other categories occupy the same rank on both lists or are within one or two in the orders.



SUBCATEGORY ANALYSIS

All entries from the 10 journals in the database were assembled according to their primary category assignments and the mission quarter during which they were written; each category was reviewed in turn and the constituent entries assigned to sub-categories, or themes, based on similar content. The results of this procedure are presented below in sections devoted to 15 of the major categories. Figures list the sub-categories within each category and illustrate the numbers of primary assignments to each one by quarter. Discussion and representative examples of entries follow for most sub-categories.



The leading subcategory within the major topic of Work is composed of entries that describe tasks performed by the crews. Examples of this large number of descriptive entries are:

I've been working about 50% with X and about 50% alone, doing lots of pre-pack operations for shuttle, routine maintenance, as well as some more interesting work. Spent a lot of time in the airlock today, doing some maintenance and checkout work in prep for the shuttle visit. Also had my first robot arm operation, and did a pretty good job in grappling a fixture on the station.

The test of the Soyuz rockets is complete. My only job was to try to film it from the window of the SM. I had a clear view of the rockets, but I didn't see them firing at all, probably because we were in bright sunlight. Didn't hear or feel anything, either, but they all worked okay.

Scheduling issues account for the second most-frequently assigned communications subcategory. These entries include many complaints about insufficient time allocated for tasks. Examples follow.

Sunday is meant to be a day of rest, but somehow Houston managed to make it feel like Monday. The problem is that I overreached myself a couple of weeks ago, feeling I was really helping out the ground to understand the problem with the ____.

The lack of "padding" in the schedule means that there is little time to accomplish small tasks, or to recover from mistakes.

Today was a hard day. Small things are getting to me. I am tired. I think that the ground is scheduling less time for tasks than before. So, there is very little, if any fat left in the schedule for me to use to catch up on little things during the day.

Only 30 minutes [were scheduled] to execute a 55-step procedure that required collecting 21 items. It took 3 or 4 hours.

Skipped breakfast and finally made up the work and time. Otherwise it would have been a fairly nice pace today.

Several of the procedures, as usual, just took much longer than timed. We have some tasks, as is too often the case, that were written without our input and which we never actually performed, except on paper.

[The Russians] save the really low-skill work for me—changing filters, cleaning fan grills, etc. I don't mind—they schedule plenty of time, so I'm not rushed, and it's somewhat relaxing.

Expressions of frustration concerning work and reactions to tedious and repetitive tasks compose the third most-frequently assigned subcategory. Note the relatively few assignments to this and the previous subcategory during the fourth quarters of expeditions. Example entries follow.

We need to figure out how to do better on inspections and maintenance. We spend a huge amount of time doing inspections and routine maintenance on several small items that should be designed to not require so much.

I had to laugh to myself at the procedures today. To replace a light bulb, I had to have safety glasses and a vacuum cleaner handy. This was in case the bulb broke. However, the actual bulb is encased in a plastic enclosure, so even if the glass bulb did break, the shards would be completely contained. Also, I had to take a photo of the installed bulb, before turning it on. Why? I have no idea! It's just the way NASA does things.

There have been no problems, yet we must periodically perform extensive inspections even though the results are always negative.

Busy work also causes me to miss home more. I think I feel less of a sense of purpose if I don't believe in the tasks that I am doing. Of course, I will continue to do them and to press on. But, it does make the days go longer.

A lot of our work right now involves inventory and stowage in prep for the launch...Not very glamorous work, but necessary. Scientific work is pretty limited.

It was a frustrating day. The urine collection started disastrously first thing this morning. I think I got about 75% in the bag; the rest was all over me. Not a good way to start the day.

I started the consumables audit—too tedious for words. I become more convinced every day that we sacrifice crew efficiency and time on orbit to make things easier/cheaper for the ground. Instead of tracking consumables, we periodically require the crew to open up a myriad of bags, take everything out, count everything, and then put it back. We ought to keep a running count.

Yesterday was painful—trash gathering. Theoretically, this should not hurt, but when they want the trash items listed off by serial number it can get a bit ridiculous.

I was not able to finish many of the tasks in the time allotted. The frustration is that so much more meaningful work could be done.

It has been a pretty tedious week with tasks that were clearly allotted too little time on the schedule. Talking to [the MCC] today, I realized he just doesn't understand how we work up here.

I have concluded that I hate to perform maintenance. Science is okay; installations are okay; maintenance sucks. The tools are inadequate and the equipment is not designed to be operationally compatible or "user friendly."

One of the reasons it gets tiring up here, I realize, is that many of the tasks we have to do are frustrating. This has to do with the way the Station was designed, how we use it differently than intended perhaps, and how the owners of each system and piece of equipment want us to do the work. The 4 hours of work to set up and take down the medical equipment is an example.

Not all entries concerning work are complaints or bland descriptions of tasks. Many entries express genuine pleasure and gratification for work gone well, especially during the first and fourth quarters of the expeditions.

Busy day today! Lots of work on the ____ system. It was really fun getting in there and working on taking things apart and putting them back together again. Seems like that is the best work we have going on! It is fun.

All in all, a very good day to end a good week. Nothing has been a “stressor” today—absolutely nothing. Work has been relaxing, accomplished well ahead of the timeline and the ground has been great to work with.

Another good day of work... everything went smoothly. Maintenance work continues with no problems.

It is also great to be getting some real science done... There have been several problems along the way toward getting this experiment operational, so it is wonderful to be getting results now.

Another great day on orbit! Conducted some very interesting experiments this afternoon...

We were an efficient crew today. I was well ahead of the timeline all day, which feels really great. The contrast between being ahead and falling behind is huge in terms of how I feel during the day.

A good day. Almost cleaned out the Task List again. Also, I got a big head start on tomorrow.

Very productive day. Everything looks good with the checkout.

The EVA was a “home run!” We did all of our tasks and then some.

I depart the Station with full satisfaction with what we accomplished and how we accomplished it. It has been a reward of complete fulfillment both professionally and personally. No major issues were encountered. No real minor issues were even encountered.

More than 80 entries expressed concern about work, usually about impending tasks.

I am a little apprehensive about this EVA. It will, in all likelihood, be my last one. I would like for it to be successful, of course. Not only for the good of the program, but also for professional and personal satisfaction. If all goes well it will be unremarkable to folks on the ground (which is good, the best result that one can hope for!). However, if we have problems, we will be remembered poorly, since it is human nature to remember the latest events.

I am ready, but a bit nervous. Lots of connections have to go right tomorrow—and be on time. We have several “bingo” points where we might have to back out if we are not far enough along. Hopefully, it won’t come to that.

My last few days aboard have been busy, but not particularly fulfilling. The end brought the typical (at least for me) rush of activity, most of which could easily have been done earlier in the increment. I had months to do certain things and did most of them in the last seven days.

Astronauts expect periods of high tempo operations and high workloads, but they also expect and eagerly await an occasional day off from their unrelenting task masters on Earth. A few examples:

Had an uneventful rendezvous and docking, but then had to work quite a few hours that day in order to unpack the Soyuz and ready it for an emergency landing if necessary. I found myself getting pretty inefficient; by the time I go to bed tonight my work day will have been about 27 hours, and that’s on top of 2 nights with pretty minimal sleep. I don’t know what could be done about it, but I think they should give us time off after docking.

One thing is for sure—I'm ready for the weekend. The past couple of days of reduced sleep and eating opportunities have added a little strain. I felt it especially yesterday. Today, the fatigue and hunger are present but not the strain.

The fatigue was evident when a couple of minor mistakes were made today on some payload activities. The ground caught the mistake and helped me out. But it is an obvious indicator of fatigue.

I haven't been saying much about our long workdays, but we're getting a lot done too. There have been many PR events as well—probably an average of once per day.

That made for about an 18-hour working day. Our working day started at midnight, by the way, just to make sure we were extra tired.

I feel that the workload is going up; these last few weeks seem to have been pretty taxing. I'm very tired.

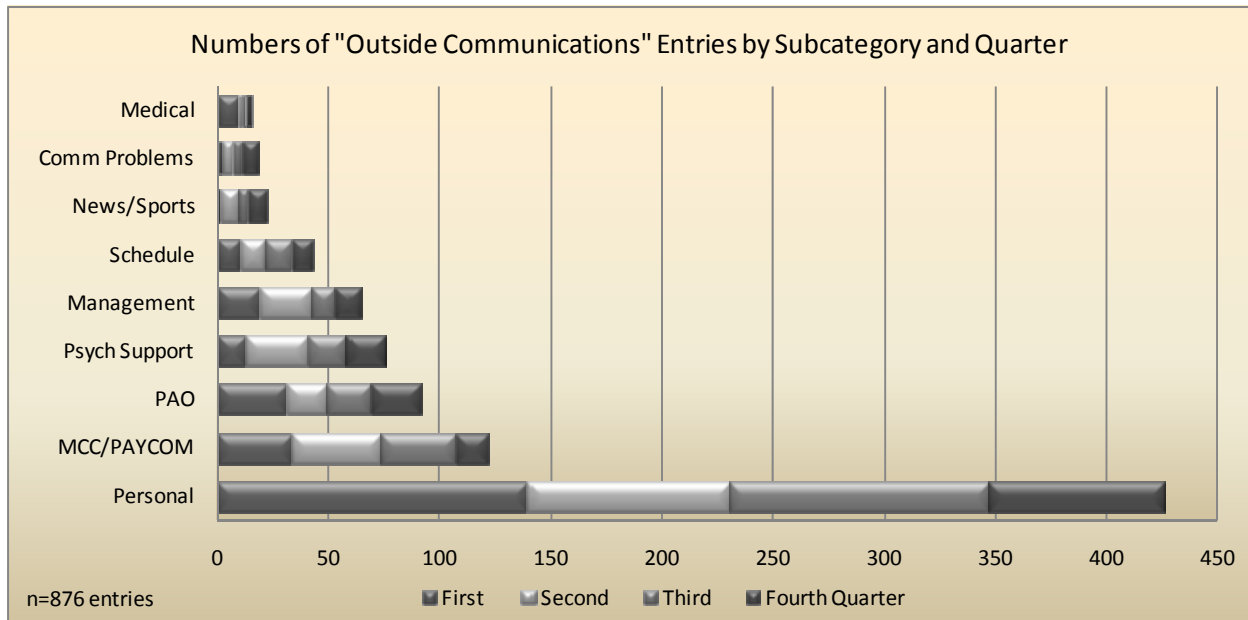
It was meant to be a day off, but Houston added payload activities, etc, so the day ended up being very busy.

It seems like I spent all day today working as fast as I could only to keep falling behind.

Everyone experiences problems at work, but only ISS crew must endure the special conditions of space and the constant scrutiny of minders while attempting to solve theirs.

When we finally got the hatch open, things started flying out like you see in the movies. We had positioned some wet and dry napkins (in small packages that were in turn in two different drawstring bags) in the DC in the event we had to clean up. When we went to vacuum, the individual bags became bloated, and all would no longer fit in the drawstring bags. This resulted in them being jettisoned from said bag. At that point they were floating free inside the DC until the hatch was opened. Then they all seemed to be sucked out into space by some invisible wind. They were accompanied by at least three rather large bolts.

I had to wait to get started, so began working on something else instead that ran into problems. Before I knew it I had 3 different partially complete things going on, which is normally fine, but the number of bags and hoses and cables and wires and boxes that were all in my way—well, I guess it got me a bit frustrated. Starting off already behind on an ambitious day is a recipe for a huge amount of stress. I sort of became aware of how stressed I was when I raced down to take a picture at the specified time. The weather was perfect, but I couldn't find the darn [target]. Eventually I did, but then I had 5 seconds to get it into the frame of the lens, and at 800mm, I tried over and over to find it, line it up, find it, line it up, find it, and failed. I slammed one of the panels with my fist in frustration and yelled something I wouldn't want on tape. This happened in front of my crew-mates and I was immediately aware that it was a display they hadn't seen from me before. It shocked me back into a reality check, and the rest of the day I tried to actively cool myself off.



Many of the entries concerning personal communications refer to email messages, but it is the availability of the IP phone onboard the ISS that is largely responsible for the extraordinary number of entries in this subcategory. Despite the positive tone of most of these entries, including the examples inserted below, astronauts also learned of natural disasters, car crashes, illnesses, and deaths of loved ones, but they preferred it to being uninformed.

Getting email certainly is appreciated.

Loving the phone we have. It makes me feel closer to home.

Had a few wonderful phone calls that absolutely made my day.

I made a couple of other calls today that were very upbeat and boosted the morale...

And the most rewarding tool here—the IP phone! What a treat to talk to family and friends! What a treat to be able to blow them away with a call from space! It brings tears of joy to my eyes every time.

This journal would be really different, if we did not have so much ability for communications. We would fall into our routines, oblivious of all the bustle and gossip on Earth, and time would fly all the faster, never distracted to worry about whether someone is going to reply in a day or so! Comm is both a blessing and a curse. Maybe JPL scientists are better off in some ways. They have to treasure the meager flow of bits they receive, like I used to treasure the infrequent scented letters from girls, with long gaps of mystery and anticipation in between. Oh, the good old days when people wrote letters.

ISS crew members communicate daily with personnel in the Mission Control Center (MCC) at the Johnson Space Center in Houston, Texas, and with payload communicators (PAYCOMs) located at the Marshall Spaceflight Center in Huntsville, Alabama. Most participants are aware that good relations between on-orbit and ground personnel can contribute to effective task performance, but the result has been a tradition that might be called “praise inflation”—profuse complements, even when undeserved, and a general avoidance of criticizing ground personnel for deficiencies, real and perceived. It seems that at least a portion of the ground personnel are more sensitive to certain remarks than the crew living in isolation and confinement, a condition known to cause hypersensitivity and exaggeration of trivial issues. Rather than facilitating the relationships, praise inflation was a source of annoyance to most of the study’s participants. Examples from the MCC/PAYCOM subcategory follow.

The ground seems to treat almost every request we make a little defensively, as if a crew request implies irritation or dissatisfaction. I will need to work on that.

X rubbed me the wrong way again. In general, he sounds patronizing and condescending on the radio, and always must have the last word. When I ask a question, he has a tendency to talk down to me as if I don't know what I'm doing.

Interesting, how you can be on top of the world one moment (literally) and then be completely demoralized the next, because of what is said on the ground.

I feel that the ground has often made my life more difficult here, thus making it hard to hand out praise on such a frequent basis. I have developed a list of folks who have gone above and beyond the call, and I plan to reward them when I return to Earth. But I feel that the praise the shuttle crews hand out is a bit overdone. If they are expecting to be praised over and over and then someone challenges their work and focus, it may be why the relationship is strained.

As the time goes on, my natural inhibition against lashing out on the radio about something that isn't going right for various reasons is noticeably reduced. I need to be careful, because I know very well that I can undo a good reputation with a single misplaced or inappropriate sentence. As it is, I sort of lashed out last week about a few things. I don't think I said anything so inappropriate, but my tone of voice and manner were not as polite as usual.

I really enjoy working with Huntsville. Nice folks and they are always enthusiastic and interested.

Today, "Scottie" as we call him, organized a tribute for me—a wonderful gesture that caught me by surprise and truly made me smile. He is full of spirit and a sense of humor. I look forward to seeing him in Huntsville after the mission.

W carries on his twice-daily arguments with his mission control center as usual, but I've learned that what appears to an American to be a dispute is actually just their normal mode of conversation. To me it's interesting to hear the difference in the US and Russian interactions. US radio conversation is minimal—sometimes we go all day without saying a word to Houston. The Russians, however, have marathon discussions on nearly every subject that comes up.

NASA provides "psychological support" to ISS astronauts in the forms of periodic video conferences with family members and occasional private conversations with celebrities (e.g., authors, actors, filmmakers), among other Crew Discretionary Events and services. The entries in this subcategory were very positive, with those few coded as negative in tone related almost exclusively to technical problems that degraded the experience. The journal entries convey sincere appreciation for these special considerations, as evident in the following examples.

It's wonderful to have the weekly video linkup with [the family]. That is sure a luxury of modern spaceflight. It makes a huge difference in morale for everyone.

I had a great PFC with my wife today. She looks so beautiful!

Really nice family conference. They sound excited that the end is in sight.

Had an absolutely delightful PFC with good video.

Had a good PFC. The family is in good spirits.

I enjoy the e-magazines that I get uplinked from the ground—they're among the best of the psych support products.

Good day today—first access to psych support web site—great video clips.

Some interesting "psych" relief was provided to me yesterday with an arranged conversation with X. I was wondering who was more nervous about talking to the other. We were both very good at breaking the ice, although I let him ask me a bunch of questions first, and then I started in on him.

Last night I had a once-in-a-lifetime experience, and I must admit, it was one that I hoped to have some time in my life, but never really expected it to happen. I spoke directly to the most famous spaceship commander of all time. It was awesome.

Relations between management and labor are occasionally strained under nearly all circumstances, but the dynamics of life onboard the ISS can render those relationships even more problematic than usual. The lack of proximity is largely addressed by frequent communications, but it is inevitable that management cannot fully understand what it is like to live and work in isolation and confinement. More important, ISS crews have two sets of managers with which to contend and often are caught in the middle of bureaucratic struggles between the space agencies. Participants in this study frequently served as unofficial diplomats to maintain good relations; one wrote that he considered it a good day when the agencies were not angry with each other and he had not overlooked something he could do to help. This subcategory included several entries by a participant who discovered that personal email messages were not as private as he had been led to believe by management personnel; it was perceived as a breach of trust and negatively influenced the participant's morale. A few examples from the management subcategory follow.

The US side tried to put words into my mouth and the Russian side tried to put words into X's mouth, fairly opposite in their conclusions. We both resisted and looked to see each other's reactions as we carefully focused our answers on simple statements. Both sides were asking us to speculate on what they should do, but I said, "We should not be asked to comment on those larger programmatic issues, because we do not have all the considerations at hand—it is your job to do that."

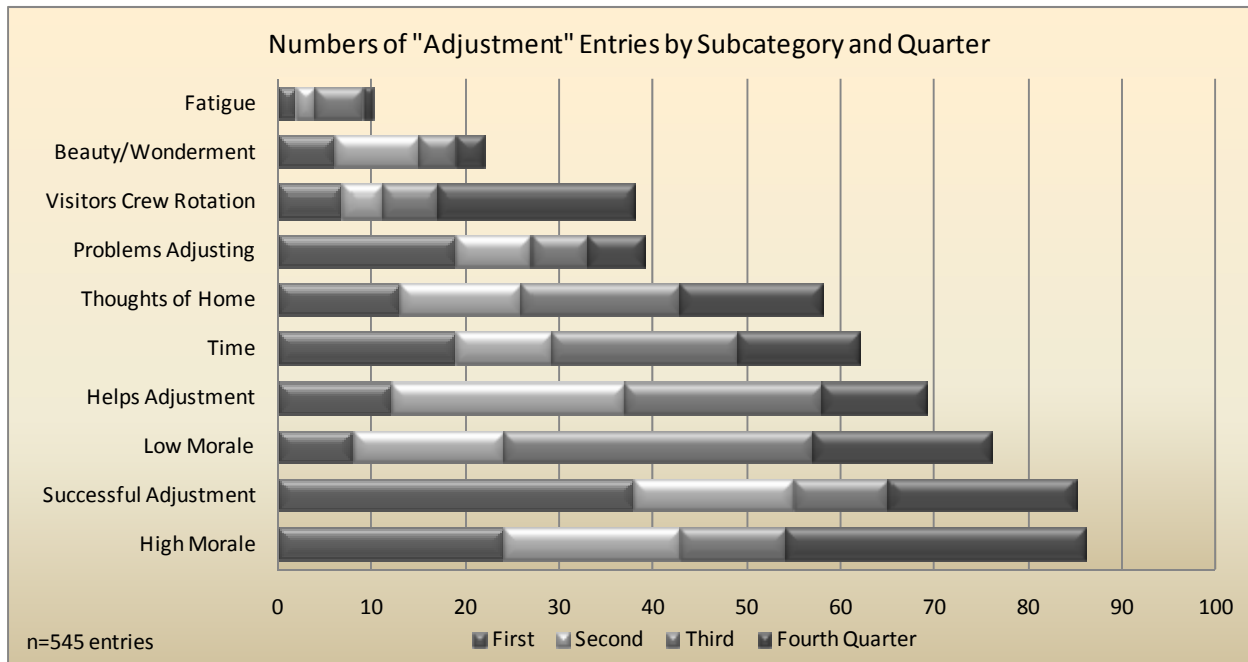
We had another open loop call from [the NASA administrator] yesterday. The 4th I think in this expedition. X always goes to sleep during them. He simply categorizes this continuous contact with US senior management as a distraction, or a chance to sleep if there is no video. He either thinks a) I am an incredibly important person or b) US management has nothing better to do with their time! A very big difference between US and Russian culture there. Neither of us can imagine [the Russian managers] making a social call to see how we are doing! For them, we are minions to be kept in line and working, and better not heard about. I appreciate the good will expressed by [NASA senior managers] giving their time. The content of the calls is not the point.

I found out a few days ago that I got a \$2000 performance bonus this year. After taxes, that will roughly pay for our mission-related party obligations. Not bad.

I had a good conference today with X. He was very supportive of our mission and activities and again conveyed his satisfaction with how we have conducted the mission and ourselves. He is the best chief that we've had.

We had a conference with the ISS Program Manager today and he seemed very happy with how things are going. He gave us some great news in that they are going to send up some ice cream—that made my day!—not only because we get ice cream but that they are looking for ways to "reward" us.





Entries assigned to the Adjustment category range from references to physical and mental fatigue to explicit comments about individual and group morale. The figure reveals disproportionate numbers of assignments to the low morale subcategory during the third quarters of expeditions and the high morale subcategory during the fourth quarters. Examples of entries concerning high and low morale are presented below.

The morale among the crew is excellent. No issues to speak of on board or with the ground.

Our mood is very good. We're off to a smooth start.

All is going very well. Morale is high, tasks are going well and we only have 30 days to go.

Spirits are high on board. Everybody is having a great time.

Another great day in space!

I have been in a good mood today. Probably lots of work makes me feel accomplished and a good workout makes me a little tired. I am ready to eat dinner and call it a night.

I am "riding high" today. Morale is very high among the entire crew. Yesterday was the highlight of the expedition.

Today was a great day! I'm not sure why.

I'm doing my best and so far all has gone really well. This is a lot of fun. It's a lot of work, but I'm still thoroughly enjoying it.

Another great day on orbit and I couldn't ask for things to be better. Morale is very high, here and on the ground, and operations are going smoothly. Overall, we are sleeping well and eating well. Our mood is great.

I feel a little lost today.

Last week was difficult and long. Probably seemed like it, because of the food situation.

I'm sure this is a natural cycle of moods and hopefully won't last very long.

ISS crewmembers and shuttle crew are not treated equally.

Too bad that ISS crews don't get the publicity that the shuttle crews seem to get!

Starting to feel like this is a little “routine.”

Stuff on the ground is also affecting my mood.

I hesitate to use the word “depression,” but it seems an appropriate description of my mood lately. Nothing seems to cheer me up much.

Perhaps this is the 3rd quarter “blues” setting in. I always figured that it would be the hardest period of the expedition. Perhaps the Shuttle crew’s return to Earth (leaving us here) has also contributed to it. I am tired of being here but have to continue to work it out so as to maintain a steady course.

Just feeling downright grumpy today. At lunch I was throwing food away because I was frustrated with how it is packed and organized. Later I was complaining about how the water sampling procedures were organized.

I can’t believe that other astronauts have not been just as frustrated as I am. Maybe they just don’t say anything.

Was in a bit of a bad mood yesterday (Sunday); perhaps a reaction to the ____ cancellation.

As the end of the mission approaches, I will no doubt start to think of all of the things I could have and should have done. One of them is to have chronicled things better—both my thoughts and emotions, and the day-to-day things that went on.

The comments he shared with me from the ground really hurt me. I have still not recovered and am not myself. I had been having quite a bit of fun up here, but the last few days have been far from fun.

I’ve been feeling slightly depressed lately, which I sort of measure by my inability to get going on a number of personal projects that I really need to make headway on. Today would have been a good opportunity. I had some free time. But I just couldn’t force myself to work on anything (beyond what I was required to do for my job).

With time on my hands for half an hour, I feel slightly melancholy, for some reason. This happens quite often in space, among astronauts in general (and cosmonauts), and space seems to somehow amplify our emotions, positive or negative, however they might be. Maybe it is the remoteness, or the beautiful scene outside, or a consciousness that we are in a unique situation, benefiting from the work of others. News stories have powerful emotional impacts on me.

The journals contained many entries that described successful physical and mental adaptation to life onboard the ISS and other entries that referred to specific factors that contributed to adjustment. Examples from these two sub-categories are included below.

Looks like we’re settling in for the long haul.

Doing great here—settling in and catching up on sleep.

All’s going great up here. They keep us very busy, but it is sure a pleasure to be doing things for real instead of just simulating them. And Zero-G is a blast! I love it.

I am excited and feel very prepared for the journey ahead. I hope to make the ground teams proud of my crew and think that, at least on the U.S. side, we have a decent shot at accomplishing that.

Adjusting to life here on ISS has been really easy; it is like coming home for me. Physically I have adapted much quicker than last time, and of course, I know most of the ropes already, except for a few that are new or changed.

I don’t feel uncomfortable at all. I feel like this is okay. There are lots of things I don’t know, but I feel confident about handling issues that come up. I am surely glad the ground is watching our backs. That really makes me feel better.

I am comfortable here now. I can fly around quickly and efficiently. I can work pretty easily in any attitude. I can read the procedures and multi-task. I am not forgetting nearly as much. I don't mind when I lose things—usually I find them in a day or so.

One thing that I am thankful of is that I haven't started noticing any resentment or anger toward the ground team or "management" or anybody else like many other crews have experienced. I continue to believe that everybody is pouring their heart into the mission. I received an email from a previous crewmember that referred to the anger of several long-duration flyers. It is a major problem for sustaining this program and I hope to find a few "secrets" to apply as a countermeasure. It is largely the same anger and resentment that periodically crops up in the training environment and it tends to act as a poison among the entire group.

Showering (or more precisely—washing with a wet towel) is an example. Just the placement of things, how I secure myself and the sequence of steps have evolved to become very efficient and easy. In this case, what I have is an empty rack location with crossed bungee cords across the front. I can do whatever I need to do in there, and I'll just bounce off the bungee cords, rather than float out into the middle of the module. So I can try to keep myself in place, or I can just float around and comfortably stay within the privacy of that volume. It works really well. In any case, the adaptation process continues, and once-in-a-while I get fed up with something that's been nagging me, and I figure out a better way to do it. It doesn't feel like camping anymore. Now it's just life.

One of the really neat things about this whole adventure is that by the time you're doing it, everyone you're doing it with is a long-time friend. This even holds true for the folks on the ground. Every voice I've heard on the radio so far has been someone who I know.

Thank goodness we have the IP phone and Email to keep in touch with our loved ones.

Happy it is the holiday and we get to drive our own schedule. That feels a little like we have some control over our lives. I think that is why it feels good.

Weekends have come to mean two things: a break from the schedule enslavement and the ticking of a countdown for return home. Initially they marked a count up but now seem to be transitioning to be more of a countdown.

I have regained my sense of humor and shrugged off the tedium. The Capcom has done a good job of disarming my potential for getting frustrated.

Suddenly I'm really appreciating the solitude that I have here. It does help to have control of your own environment if you're going to be isolated. I'm trying to picture what it would be like up here with a crew of 6. It would be totally, completely, absolutely different. It would be more fun at times, and there would be more camaraderie. That would be positive. But, the entire US segment is the equivalent of my house right now and sharing it would be huge difference. We are very lucky to be here a time when the Station is so huge, yet there are only 3 of us to share it. This is quite a luxury!

Today, I am glad we have normal work to do. The time goes by better and I feel more cheerful, with the little ups and downs of getting the day's plan accomplished.

It was a well-timed event personally, because it brought me out of a state of "blues" that had been hanging over me all day. I woke up this morning thinking, "OK I don't want to 'play' anymore. I just want to be home sleeping in our bed, eating at the dining table, sitting in my recliner."

Some words that have helped came from my friend ____, who flew last year. He said "At this particular time, you just have to start letting go. It's time to move on, and you can't hold onto the role that you had, so don't even try. Instead take comfort in knowing that you did a good job and that it's time to come home."

I blew off some steam by sending Emails to some close confidants. I suppose this will be a good test to see if they are reading every note.

I realize that often times I use this journal to vent my frustrations. This helps me collect my composure to deal with the situations. I must continue to look at the big picture and count myself lucky to be here.

I think it is good to write this down—typing gets out some of these frustrations.

Writing in this journal helps to let off steam!

Examples of the more than 60 entries that referred to the passage of time are listed below. It appears that the transition from counting up to counting down occurs at about the four-month point and there is general agreement that six months is a long time to be away from home.

Day 16 in space.

Twenty days? The time is flying by.

I can't believe I've been up here for 3 weeks already.

Now that we have passed the first month, I note that we have 5 to go.

Well, our sixth week draws to a close. We've accomplished a lot.

We are 2 months down; 4 to go— $\frac{1}{3}$ of the way through!

Hard to believe we're into our eleventh week on orbit.

Well, I made to 100 days. At this moment my watch says 100 days, 0 hours, 54 minutes, 29 seconds since blast off. I can hardly believe it.

We are approaching the half-way point in our voyage.

Three months in orbit! It seems like it's gone by pretty quickly at times, and somewhat slowly at times. In any case, our mission is roughly half over.

Today is the 4 month point!

Seven weeks from tomorrow, we are scheduled to land.

Under 40 days to go before landing!

Still trying to stay out of the "countdown" mode, but it's getting harder. In fact, we still have over a month to go.

I still think that the ideal space station mission length (for me) would be three months. It would be a different story if we were going somewhere (moon/mars)!

I'm starting to understand why people have said that 3 months is the ideal mission duration.

I can honestly say that I'm ready to go home. For me personally, five months would be the ideal flight; six is a bit long.

The only way I am remembering the dates is when I enter something into this journal.

A few examples of entries concerning problems adjusting to life onboard the ISS are listed below.

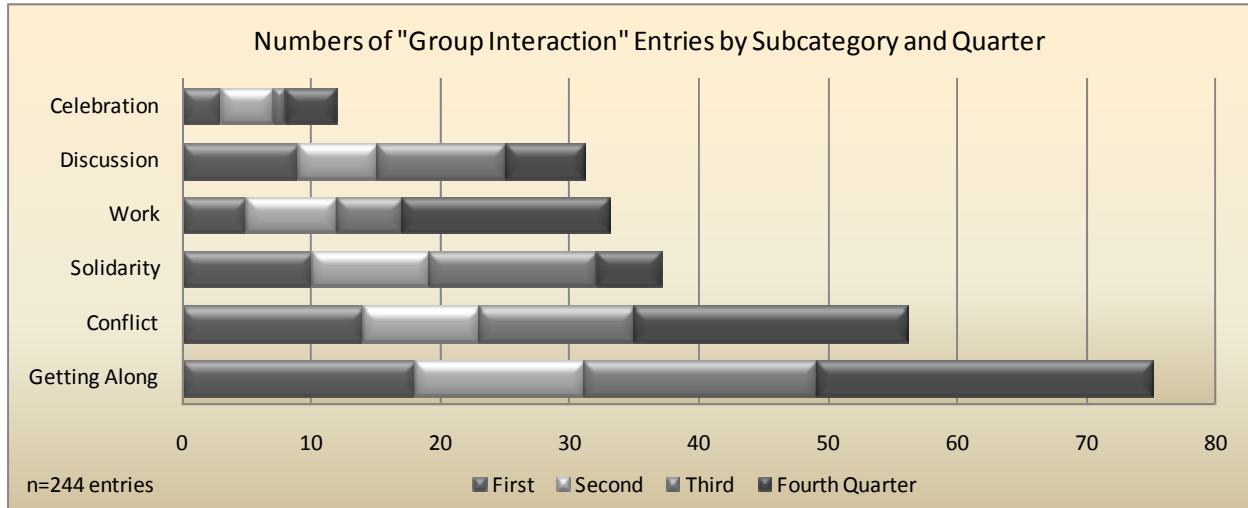
This place is really an emotional rollercoaster for me.

There is so much going on that I feel overwhelmed. I am worried that I don't remember as much of my training as I should. I am looking forward to the pace slowing a bit, so that I can settle in.

One of the problems is that our training doesn't really cover some of the basics of life in orbit that we need to have under control. We spend all of our time on emergency scenarios and spacewalks. Sometimes understanding how to live would go a long way to increasing the success of the mission.

I think this would be frustrating regardless of where I was, but I definitely need to let go of this and forget about it.

I believe I have learned that I do not have what it takes to be a long duration crewmember. I have accomplished much up here, and I am proud of that, but I don't believe my future is in long duration.



Nearly all of the participants in this study wrote prior to launch that getting along with their crewmates would be their highest priority. It is evident from the journals that astronauts and cosmonauts shared this objective and actively worked to maintain interpersonal harmony by cooperating, avoiding certain topics in conversation, and other sincere acts of comradeship. Perhaps they were aware of what twice Hero of the Soviet Union, Cosmonaut Valery Ryumin, wrote in his journal during a particularly difficult period onboard the Salyut 6 space station: "All the conditions necessary for murder are met if you shut two men in a cabin measuring 18 feet by 20 and leave them together for two months." The Russians and Americans got along fine together nearly all of the time and, for this reason, most of the entries concerning conflict describe disagreements between astronauts. Examples of getting along and interpersonal conflict are provided below.

W and I are getting along well. We did some tasks together and everything worked okay.

X and I continue to get along very well and have a few laughs now and then.

Y is in a particularly good mood this evening which is already making a positive impact on me.

Everything is fine with Z and me—I don't think either of us gets on the other's nerves too much.

I have to say, I'm pretty lucky. At 108 days I'm not the least bit annoyed or tired of these guys.

The crew dynamic on board is excellent.

The crew interaction on board was near perfect, as was the interaction among the on-board crew and the ground teams. Never did any kind of issue arise between crewmembers.

We had our first heated discussion, yesterday. It was over lunch and he flew off very emphatically that irresponsible scientists [were] trying to find favor with politicians—I am not sure if we were getting towards oil and global warming, but he went on for about 5 minutes, got interrupted by an activity he had to do, and came back to say he realized he had been very adamant, but he felt it was all a big problem with scientists pushing theories as fact to a gullible populace, and worse, scheming politicians. I just listened and let it all calm down. I cannot afford to have arguments of any type with [my crewmate].

I was really surprised this morning to find that X had completely failed to perform a task yesterday, one required in order for me to perform a task this morning. I was quite angry and later apologized and accepted responsibility for not “monitoring” more closely. I’m still disappointed that X never took responsibility for the mistake.

Had a 5 minute break. Went to grab some coffee. Y has now decided not to have the water heater on continuously, so had no hot water. Again amazed by how inconsiderate Y is.

We did have a run-in one night. I was really livid after Z snapped at me quite viciously about something that wasn’t my fault. I let Z have it, like I can’t remember ever before in a professional relationship, and stormed off.

We moved some racks together today, in the morning and throughout that entire process U was barking at me constantly.

I’m finding myself losing tolerance for T. I can’t explain exactly what it is that bothers me.

I feel like I am complaining in these journals, and maybe that is what they are for. But regardless, I am lucky I have this opportunity and it will be gone before I know it, so I am enjoying it to the maximum I can—even with the ____ I have to stay here with.

The essence of the group interaction described in the journals is not found in the preceding entries concerning conflict, but rather, in the entries about solidarity, teamwork, and celebrations. Examples:

We’ve got to take care of each other. I admire his concern for making sure that I’ve eaten. We make a good crew.

I notice X is very consistent to answer honestly each morning, when I float in to the SM, how he slept, after saying good morning. I do the same for him and it seems we both always ask the other, if that was left out. X also is pretty good at telling me spontaneously if he has been having a couple of bad days.

It is good that we have this kind of relationship. This mission is so easy, since we are of like personality and thought.

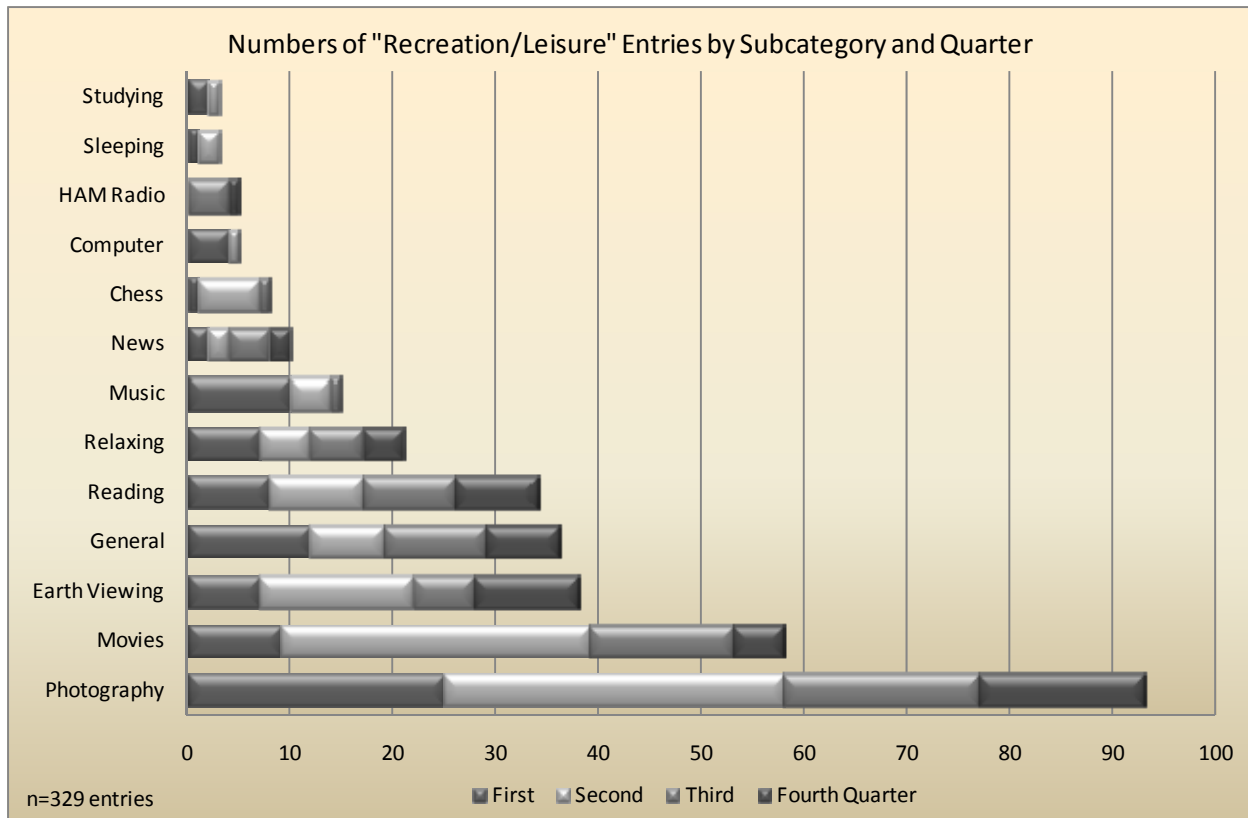
I’m grateful that Z and I launched having built a strong personal relationship. That has been important in helping us deal with the stresses of adjusting to being here, exacerbated by the intensity of our first two months on orbit.

W is amazing as a crewmate. Nothing fazes his even demeanor and steady work. He is just a great guy to be stuck in a “tin can” with for six months.

It seems like the EVA stuff bonds folks. We feel each other’s pain and understand the hardships associated with what we are doing.

We have some inside jokes; we talk about the other cosmonauts and astronauts, which seems to be a favorite topic for him. We watch movies together on the weekend nights. S and I had some longer talks, but that is possible because his English is so good.

Tonight we celebrated our last night together as Expedition xx. There wasn’t much emotion, but perhaps a bit more than usual. M seemed to want to say, “I love you, man,” without the alcohol to us both. He commented on how much he liked how we all lived together. When I asked him what characteristic he would use to describe what he liked, he answered that it was laid back (my translation). I guess he’s right, but at the same time it’s a little difficult to imagine things being otherwise. My only other experiences have been short duration flights, where the pace just doesn’t allow the seeds of conflict to germinate. Our time together has been remarkably conflict free; W and I did have words a couple of times, but never once with M and never even felt anything remotely close to having to bite my lip. I don’t know if it’s always that way.



More pages have been written about recreation in space than any other behavioral issue, most during the 1960s when it was assumed that an expedition to Mars would follow a successful Apollo Program. The emphasis on leisure activity reflected the widely-held belief that astronauts would be at psychological risk during interplanetary voyages and heeded admonitions from the past that boredom was the primary enemy of polar explorers.⁷

An expedition to the Moon, Mars, or an asteroid would present opportunities for unstructured time and idle hands to work their legendary mischief, especially if equipment malfunctions, atmospheric conditions, or some other factor prevented performance of scheduled tasks and resulted in prolonged periods without meaningful work. The importance of meaningful work to adjustment and morale is evident in many of the journal entries included as examples in this report. However, all participants complained about trivial, redundant, and tedious tasks, but few complained about the low workload periods that are typically experienced during the latter stages of transferring responsibility for the ISS to a replacement crew. The high-tempo of scheduled work usually limited the participating crews' leisure time, which was put to good use when available, as described in the entries reproduced below.

References to Earth viewing and photography accounted for 40 percent of all entries assigned to Recreation and Leisure as the primary category. The preeminence of these activities, which are essentially the theoretical and applied versions of the same pursuit, was predicted by previous spacecraft and space analog experience. The *Skylab* crews spent nearly all of their free time at their window and recommended bubble-like observation domes on future stations, and the cupola that was (finally) installed on the ISS in March 2010 was inspired by the most popular design feature on NASA's 1969-1970 *Tektite* undersea habitat.

⁷ For more on this topic see Chapter 14, "Recreational Opportunities" in, Stuster, J. *Bold Endeavors: Lessons From Polar and Space Exploration*. US Naval Institute Press: Annapolis, MD, 1996.

Deriving pleasure from observing nature probably is hardwired, which when coupled with Type-A personalities, a great view, and a camera with an 800 mm lens has resulted in a zillion extraordinary images of our planet and contributed to the habitability of the ISS for many astronauts. NASA's Crew Earth Observations (CEO) program specifies targets of interest for the astronauts to photograph (e.g., Mt. Kilimanjaro without cloud cover, wildfires in California, a hurricane approaching the Gulf Coast). The target opportunities are hard-scheduled and performance of the tasks inspires most astronauts to develop skill with the powerful lens and then to capture images of their own choosing. The results have been an enormous catalog of interesting and beautiful images (84 percent of which were selected by the astronauts), and the complete elimination of boredom as an enemy for most ISS personnel. The availability of Earth photography opportunities, which are determined by orbital dynamics and weather even influences individual morale. It is important to note that this source of recreation and personal gratification will be less available to interplanetary explorers during long periods of their voyages.

Traveling around the globe every 90 minutes provides lots of opportunity to view the geography, oceans, cloud formations, sunrises and sunsets, thunderstorms, city lights and many other things in vivid detail. In both the Russian Segment and the US Segment of the Station we have a computer map program running to show us where we are and to provide prediction for future passes over specific sites on the Earth.

We are in what X calls "boring orbits." Our orbit is such that we are mostly over oceans by day and continents by night. About the only land we see is southern South America and Australia.

I am trying to make more time for photographing the earth. It is enjoyable and useful, with tangible results.

I am getting some good photos of the Earth. It is interesting work. On my shuttle flights, there was never time to experiment and to get into the details of photography. Now that I have more time, especially on the weekends, I can experiment with settings and exposures and lenses to see what works best.

At least I have my new hobby, photography of the Earth. It's really exciting and I look forward to getting good shots!

I took a peek out the side-facing JEM windows one evening, without camera in hand, and was so mesmerized that I ended up gazing upon the Earth for an entire 90 minute orbit. A hundred times I thought "I should go grab the camera" but I decided to just try to capture this one orbit with my own eyes and burn it into my brain.

This is a point of irritation for crews—they built us a great window, but we're not supposed to use it unless MCC directs us to.

I finally photographed a place that I have tried to spot for a week. It's called Kerguelen Island, a French research outpost in the South Indian Ocean. There's a small cadre of researchers there, supplied by a ship every few months. Sort of like a station expedition. It's almost always cloudy there, but today I got a nice photo of most of the island. I think I'll try to email it to the folks there. [Note: The physician and leader of this research station in 1993 participated in the experiment, described previously, on which the current study is based.]

In a space of 20 minutes we flew directly over the Cape of Good Hope, the tip of the Horn of Africa, and K2 (second tallest mountain on Earth). I got photos of all three places.

I have been looking at the Earth, from the point of view of a visiting extraterrestrial. Where would I put down, and how would I go about making contact? The least dangerous thing would be to board the International Space Station and talk to those people first.

I think I'm going to spend the rest of my life trying to understand what I saw here every day for 6 months. It's become a ritual for me, on my way home from the Service Module at night, to take a detour and stop in the Russian Docking Compartment to stare out the window before I go to bed. The view is awe-inspiring and beyond comprehension.

We're flying sideways again, and we're in an orbital phase where the Sun is never very high in the sky and where we see mostly Patagonia. But I just got my first ever glimpse of the South Georgia Islands! These islands were the location of a whaling base for many years, and are probably best known as the site of Shackleton's trek overland to find help for his crew.

[Note: Ernest Shackleton, the most revered polar explorer, never made it to a planned destination, but he never lost a man, either.]

By some strange coincidence, in one day, I saw most of the places I've ever lived. Not only did I see them, but I captured some extremely clear pictures.

Photography has been disappointing lately. The earth is very smoggy these days, especially over coastal China. There, I literally can't get an even semi-clear image of the land form through the smog, even when directly nadir. The US and Europe have been covered with clouds. It's definitely winter time on Earth!

Haven't had much chance to look out the window lately, but our orbit is definitely getting more scenic. We're starting to cross Europe and North America in daylight, and we've had lots of good passes over Africa and the Middle East.

Our orbit does not currently provide for very interesting Earth observation photos. However, I caught some nice shots of the moon descending towards and through the Earth limb. Pretty spectacular!

The orbits are starting to get interesting again. It is time to try to get the last photos that I need to round out my collection. In reality, I have most of them [already]. It's still the most enjoyable thing that I do onboard.

So many pictures have now been taken of the earth that very rarely do we get requests to take big wide field of view pictures, with the Earth's curve in view. After a while, I decided to take pictures for myself of the curve of the earth with a big horizon, looking on the line of travel of the station. Wow, it is great to do this. The view is like being in the nose of an airplane, head out in front. I use a 17mm lens, which is wide angle enough to produce an image just as the eyes see the scene. I take a series of pictures, every 30 seconds or so for the last quarter of an orbit, as we go toward darkness and the terminator. The result is a series of pictures that reproduces the path of the station over the Earth that I can review and marvel at. Yes, they are not as good as the real scene, but the key is that they are a record of what I have seen, and will be with me after flight to remind me.

We're still getting lots of views of North America out the window. I've given up on trying to get good photos—it's much more pleasant just to watch.

Watching movies together was the second-most frequently reported form of recreation by the astronauts and continues a tradition of group entertainment that has been enjoyed by remote duty personnel since soon after the advent of the medium. Films worn from repeated showings at Antarctic stations were creatively re-spliced with hilarious results in the decades before videotape players. ISS crews have benefitted immensely from the availability of a plasma screen, stereo system, and laptop computer capable of playing DVDs. The camaraderie and group solidarity that result from "movie nights" are evident in the entries that compose this subcategory, as is the sensitivity of the astronauts to the feelings of their Russian comrades; that is, considerable effort is devoted to the goal of avoiding interpersonal conflict, which extends to careful selection of the movies a crew views together. It also is evident from the entries that the 1968 Stanley Kubrick/Arthur C. Clarke classic, *2001: A Space Odyssey* and the 1984 sequel *2010* are considered to be the best movies about space exploration, at least by this sample of experts.

On Saturday I showed *2001 a Space Odyssey* to X, as we have been talking a lot about space exploration. What a class movie. No stars visible; airlock ops, maneuvers, all just right on. We really felt for Bowman, all alone, no return without going to Jupiter first, and doing the manly thing—carrying the mission through.

Saturday night we watched a contemporary Russian movie for 3 hours—with good Soviet-capitalist type discussion of the value of the Russian aristocracy.

Z and I agreed this would be an opportunity to watch movies, and we did, 3 nights in a row.

We watched another movie this weekend. I was not sure Q was in the mood, as he had been rather gloomy, probably for similar reasons as mine, so I decided I would not bring it up. However, he suddenly seemed to wake up at dinner on Saturday and proposed setting it up, but not proposing any film in particular.

So the movies filled the time. We watched *East West*—a Russian French movie set in Stalin's Soviet Union in Russian and French with Russian subtitles. I realized as we were watching how the hero, a Russian émigré returning to Russia and his French wife and son were being abused and moving through a very frustrating and sad life, that M was not going to be happy with it.

X and I continue watching movies about 4 nights a week. Usually it takes 2 sessions to finish a film. We've been watching mostly American films, since our Russian selection is pretty poor.

I uncertainly proposed *The Right Stuff*. Not a very good movie and did much to overinflate the already huge egos of test pilot astronauts worldwide. The characters, other than Glenn, are not very nice people, as portrayed. However, Y jumped at it, and even though the flying scenes and the launches were unrealistic, he said he enjoyed the movie.

We had not watched a flick in a couple of weeks, but we renewed our movie habit tonight, watching the first half of *Master and Commander*. It's a bit hard for X to understand the nineteenth century navy jargon, but it's a good movie.

We watched the first half of *Silverado* last night, but I don't think I want to watch the second half tonight, since I really need to do my prep for tomorrow. But, I guess I could be talked into it.

We watched *True Lies* tonight—it was a fun movie. I had forgotten most of it and can't help but think about Tony Robbins' commentary on why we watch movies that we've already seen. Since we know the outcome, it is predictable, and it is a comfortable feeling when your life and your environment are predictable. But we also need uncertainty to keep us active, alert, and stimulated. So we hope that we forgot enough of the movie that we find it exciting even though we already know what's going to happen. It works! It was exciting and also predictable.

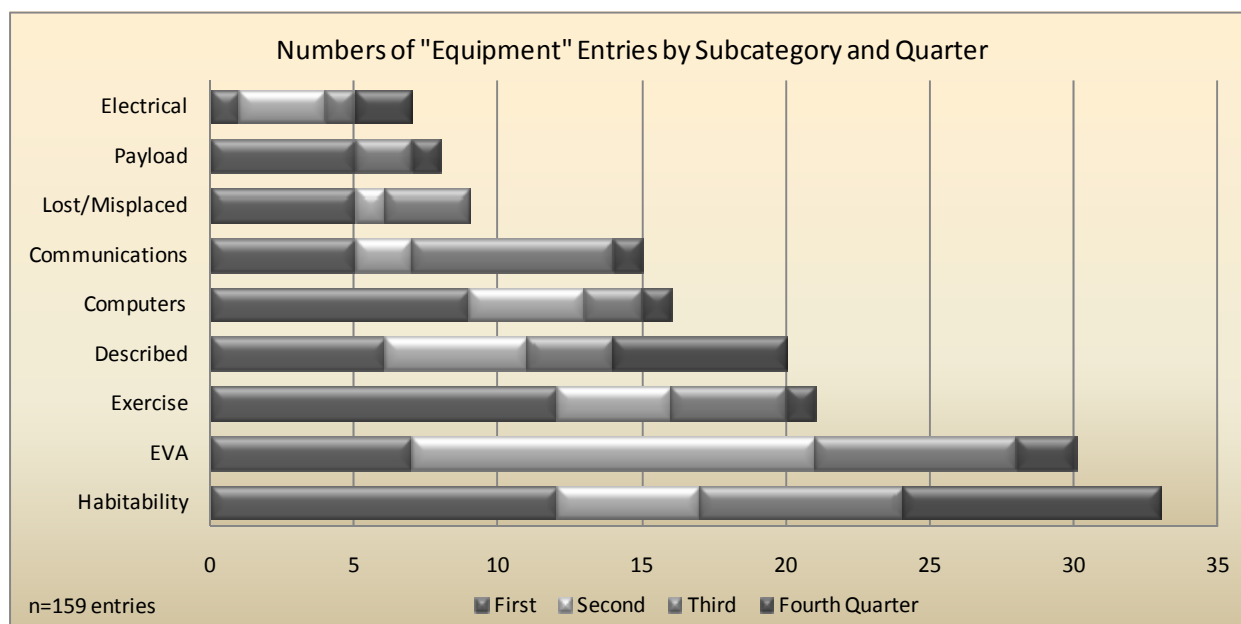
I'm dragging [my crewmates] through all the Star Trek movies. It's been a lot of fun to be the lucky person to introduce Star Trek to a couple of Space enthusiasts who never had the opportunity to see how we made the dream come alive on TV and on the big screen in America. A few movies back, when Spock's father took leave of him after saving the planet, the two Vulcans raised their hands, did the Vulcan salute, and said the proverbial "Live Long and Prosper." I died laughing as [they] spontaneously tried to give the same salute. To see them doing something for the first time that I did for the first time about 40 years ago was unbelievably funny and nostalgic. They are really into this and I'm having a great time showing it to them.

We watched *2010*, in part because we started with *2001*. Y seemed to enjoy Hollywood's depiction of the Russians, who save the mission and deliver our American heroes to Jupiter.

After our EVAs were over, we had a day and a half off. It was one of the first times in which we had some time off 2 days in a row during the mission, so we planned dinner and a movie night.

The movie *2010* was fun to watch because it was about a joint US-Russian mission. So we were a joint US-Russian crew watching a joint US-Russian crew, and enjoying all the inter-cultural exchanges and how they were portrayed in the movie. In particular, when they had to sever relations and stay on their own ships due to the breakdown in the political situation on Earth, we started joking about how we would do that up here—and I was in big trouble with the bathroom, oxygen generator, and rescue vehicle across the border. It really is amazing that we are here, Russians and Americans, on a massive international spaceship. We might not be orbiting Jupiter, but 40 years after *2001* came out, the barely imaginable has become absolutely real.

In addition to Earth viewing, photography, and watching movies together, the astronauts' journals contained many references to reading, listening to music, and catching up on news from Earth. Some of the astronauts devised guessing games and trivia contests to engage and entertain their ground controllers, and one participant started a game of chess with ground personnel that quickly spread to the Russian MCC and eventually blossomed into an international, Earth vs. Space tournament. Others spent off-duty time contacting HAM radio operators, communicating with friends and family, or preparing collections of images and video to document their expeditions. It also is apparent that most of the participants devoted considerable free time to maintaining the personal journals that are the subject of this study.



The journal entries assigned to the Equipment category mostly refer to problems, rather than the smooth functioning of machinery and other systems, although some describe the joy that accompanies a difficult but successful repair. The topics range from habitability and life support equipment to the limitations of disposable batteries in space. Examples from the sub-categories are provided below.

We looked at it, cleared it—and presto, we have a decent table now that does not knock you while running on TVIS, and its built-in fan and heaters work! He said, “Why did you not mention this earlier?!” We are pleased and will carefully store the pieces in the FGB, behind a panel.

There’s only room for two at the table, so three of us just float and juggle our food. I’m not sure what the idea is for when we have six of us up here.

After a week here, I notice the noise on the ISS. It is markedly louder in the SM, where I wear ear plugs all the time. In the USOS, it is quieter, but still loud near the aft end of the lab. Fortunately, inside the TESS is very quiet. In the USOS, I generally wear ear plugs too, but I do give my ears stretches without. Wearing ear plugs constantly irritates the ears, so some breaks are necessary.

I will mention a relatively minor thing that is starting to become an irritant. That is the high-pitched loud noise that comes from the ___ rack. I’m pretty sure it is the ___ pump and it is way too loud. One of the environmental things I miss the most is quiet—complete silence. Unfortunately my primary work place is right in front of it because of its proximity to the ___ panel and the laptop I use most.

We had a tag-up today to discuss options. There aren’t many. None of the other gloves onboard is a better fit. The EVA may be at risk.

During the day, the Service Module feels like a steam bath. Usually there are 4 or more people in there, and the systems are just not keeping up to maintain temperature, humidity, and CO2 under control. As I fly through the Station and enter the SM, it feels like running into a blanket of muggy stale air. I am very glad that my work is generally elsewhere.

We heard the usual clicks over the loudspeakers, a byproduct of the relays operating, and X floated nearby, and then said, "Over here—it is the smell again." It was like you had your face in a can of paint. This is very dangerous, so I said we should turn it off and close the valves now. X seemed uncertain, and I said we can't let it go on. He reported the smell as coming from ___ just before we lost comm with Moscow. They came right back and said shut it down; I was relieved.

Physically, I am exhausted. My arms and hands are somewhat beat up and worn out. The suit could have fit better.

So, at the moment we have no systems working to purify and circulate our air, control temperature, or generate oxygen. This all comes after a separator pump failure last night that knocked out our toilet. We do have spares onboard and hope that replacing the separator will solve the problem. In the meantime, we are using the Soyuz facility, which has very little capacity. When it rains it pours. Until today, Survival Mode was just the name of a mode of the Command and Control Computers, which I had to understand theoretically. It's taken on a more substantial meaning for me today.

M was tired even before we started. His cooling failed twice, causing him to egress the suit and troubleshoot connections, etc. Problem was a chronic bend in a water tube, one that M thought should have been fixed long ago after the problem plagued someone else. That added being frustrated to being tired, and put us over an hour behind before we ever opened the hatch.

The biggest news here was a meltdown of the file server yesterday. The biggest impact has been a loss of email for a day. It happened just after I composed and launched a bunch of emails.

So many laptops have failed that we now have to scavenge. Psychologically, this is significant because I am now effectively computerless in the SM, so spend my browsing time in the Lab away from X. It feels strange—only meals and the toilet lead me to the SM now.

We almost had another "upset" for the weekend when our OCA Router died today. Fortunately we recovered with a reboot. I believe the parts are overheating and need to be replaced.

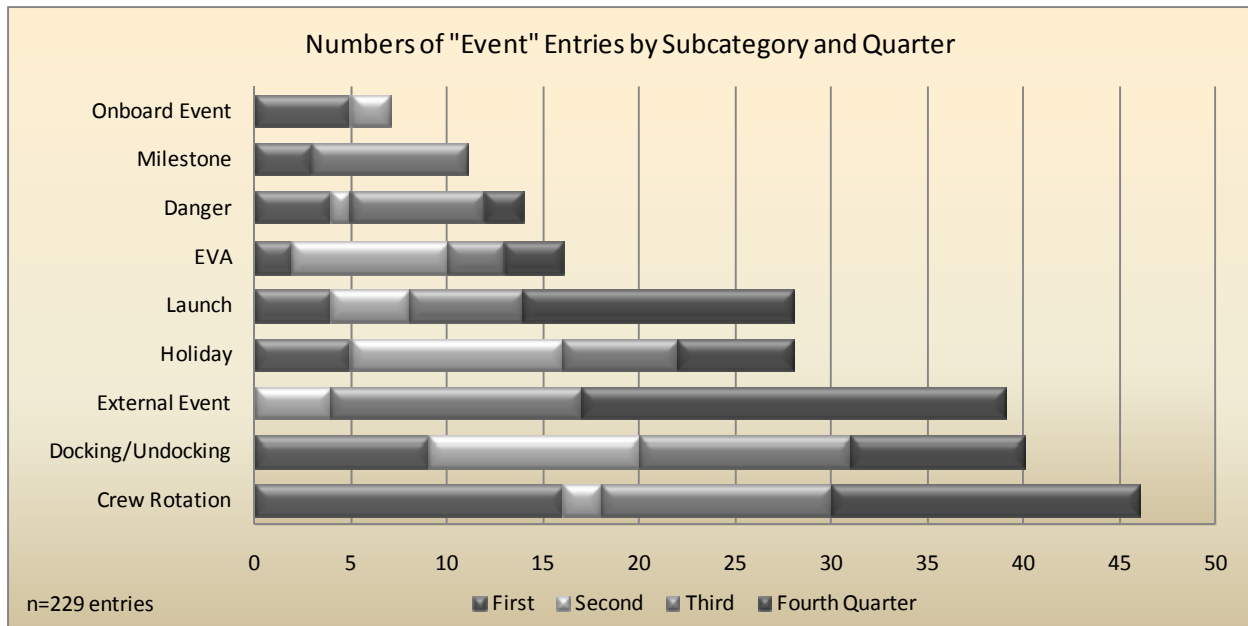
The only irritant I continue to work through is the TVIS and the discomfort with the harness while running. Being a lover of running it is very frustrating. I also worry that it might cause long-term damage to my hips.

Latest pet peeve: I don't think we can get to the Moon and Mars on disposable batteries.

The connectors are gamma type, which translates into being a royal pain in the ass. T said the only reason that you need to timeline two folks to do this is so that one person can swear full-time. At one point, we thought we might need to get Y, so that we could have 2 people swearing!



William Clark Writing in His Journal at Eagle Creek, 31 May 1805,
by Gary R. Lucy.



Event emerged as a category during the coding of the French diaries to accommodate periodic external and internal influences on crew behavior. For example, storms that confined an expedition to its habitat or destroyed equipment usually had a cascading sequence of consequences. Some events that influence ISS crews are reasonably predictable, such as Shuttle, Soyuz, and Progress launches; docking/undocking; crew rotations; and holidays, while others are not, such as onboard emergencies, increased solar activity, and hurricanes that threaten friends and family on Earth (and affect station operations). The disproportionate numbers of entries concerning crew rotation during the first and fourth quarters, illustrated in the figure, reflect the salient experiences of replacing the previous crew and being replaced by the next crew, respectively. A few examples from the sub-categories follow.

Well, we're finally here. The launch met all my expectations. Damned small vehicle.

The Space Station is no longer a peaceful and quite place anymore. There are busy people everywhere and in all directions. It was an amazing sight to see the Shuttle pull into view below the Station. It wasn't at all like watching a Soyuz or Progress. The Shuttle is a gorgeous and huge spaceship by comparison, and so much more capable. It brought tears to my eyes, and I couldn't help but think of it as my ride home at that moment.

Another tumultuous day. We said goodbye to our crewmates and I was sad to see them go.

It is difficult having the place raided and in such an upheaval. It will take the rest of the expedition to regain order I'm sure.

The Soyuz approach was absolutely amazing. They approach the near phase hot with jets blasting away to slow the craft and capture the station-keeping target prior to the fly around.

It felt like a scene from *2001*! The Soyuz seats three abreast. The commander sits in the center seat; I'm in the left seat with a duplicate computer display, entry keypad, a set of unique direct command keys, but no flight controls.

This attitude really screws up Ku coverage. I really hate it.

I have been "on top of the world" since watching the Soyuz launch this morning and knowing that relief is on the way. We also are enjoying watching the Shuttle trail behind us. What a great docked mission that was.

We are beginning to ramp up with the EVA preparations. I am looking forward to this one more than the last, because I feel more in control with what we are doing.

Today is EVA day. I'm starting to have that I-think-I-must-be-forgetting-something feeling. MCC-M just called to disallow me from using the _____. It's too close to the EVA to let myself get upset, but I can tell that I will be. It's all about "not invented here."

We heard a big bump in the morning yesterday that we think could have been a meteor strike.

Lots of radiation flashes bothered me last night.

Today is the third day of unexpected solar flare activity. We had to take shelter in designated areas inside of ISS.

I always knew that this could happen [another solar flare] and it is a little disconcerting. However, there is nothing we can do about it. If we had been on a mission to the Moon or Mars, we would have taken the full brunt of the radiation. That is a problem for which we don't have a good solution as of yet.

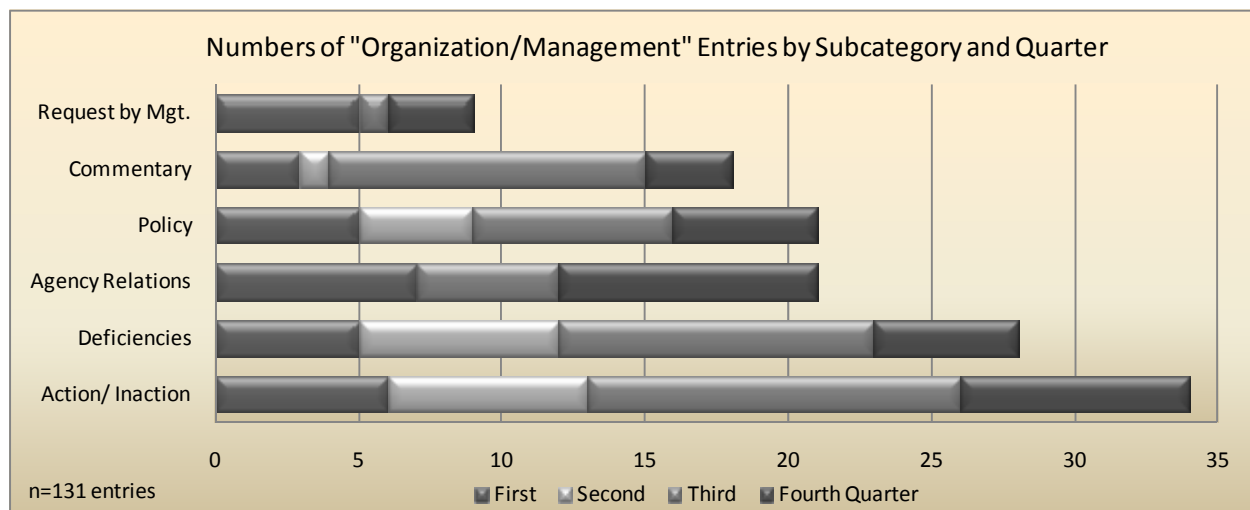
All is well on board, at least now it is. We had a fire—or at least smoke—out of the _____ that caused a little commotion for a couple of hours. It was brought under control right away, we never had to don masks and the filtering of the atmosphere was completed quickly.

My 100-day party is coming up this week. That will be an interesting and fun event. I'm not sure how it will be to interact with a big group from here, but I'm psyched we're having a party.

Happy New Year! We've really enjoyed our time off.

New Year's Eve is over, I must say with some relief. I was aware that it was as important for X's family as Christmas was for mine, so I suggested activities. He invited me to join his family video conference, and I politely waved and joked for 15 minutes or so and then discretely left.

I am not sure I look forward to Holidays on ISS, especially those that are not followed by a weekend. The effort is made to be happy and people on the ground go out of their way to help each other and us, but the effect is to fill the Holiday with a lot of friendly social stuff, chatter on the air to ground, some expectancy for a little show from the crew, VIP telephone calls etc. Meanwhile the things you really count on, like email updates, swift responses to your questions about work matters etc. degrade, because the ground teams have gone to [partial staffing]. Unlike on Earth where this would be enjoyable, because you do not have to work, here it is spoiled because there are always high priority work tasks that just cannot wait until the next day. I can clearly see from my whining here that time pressure is the biggest factor affecting my mood.



Communicating with management was addressed in the discussion of Outside Communications. In contrast, the major category labeled Organization/Management is composed of entries concerning management actions, policies, and relations between the space agencies. Examples follow.

This is actually a source of some frustration for station crews—they train us for years, but when the shuttle crew comes up they do most of the operational work.

I still get frustrated by the degree to which we get left out of the loop. This has been a perpetual problem in the ISS crew world.

Contrary to the briefing last night, the ground wanted to begin arm motion earlier than scheduled, prior to my availability. This certainly did nothing to give me confidence in the ground team and reinforces my belief that the ground too often fails to consider the crew when making decisions and taking action.

Something that Houston has continued to do that is a little irritating, is cancel events for me because of a perception that I am too busy. Yes, I do have a full work schedule, but Houston is canceling fun events, like talking to celebrities and doing interviews. I sent our folks a polite note asking them to let me do these things. I am not too busy.

Although there are a lot of seemingly little things (it's hard to gauge how big they are, being too close to it all) that are bothering me about NASA, I must not let it get to me.

I continue to be amazed by the degree to which the ground has gotten into the habit of taking action and not informing the crew.

It's difficult to put up with what I see as tasks that waste my time, while other things that I want to do fall off as lower priority. I am in a difficult position, in that if I want to discuss these issues with the ground, I may be perceived as grumpy or complaining.

The expectation is that I'll just do the right thing, regardless. I would expect at least some interest in identifying obsolescence with an eye toward correcting it in the future. It doesn't happen.

I learned today during the weekly planning conference that my schedule is so packed that they had to schedule 3.5 hours of work for me on one of my upcoming days off. This is a bit irritating. I wasted so much time this week and to now take it out of my scheduled time off is going a bit far.

I get the feeling the US and Russian teams are a little stressed with each other. An incredibly unnecessary and pedantic US procedure to ____ should have no consequence to the Russian side, but my whole morning activity carrying out this procedure was cancelled, because it involved X helping me read a meter for 5 minutes, so opening the door to have the Russians review and probably ridicule the US procedure. Houston simply told me when I pressed them that the Russians had not blessed the procedure, and I jumped to these conclusions. It is probably a reaction by the Russians to Houston nagging Moscow about the upcoming ____, making them take a bit of their own medicine. I am not sure what X and I can do to ease all this. At least we can work together calmly and make that evident to Moscow and Houston.

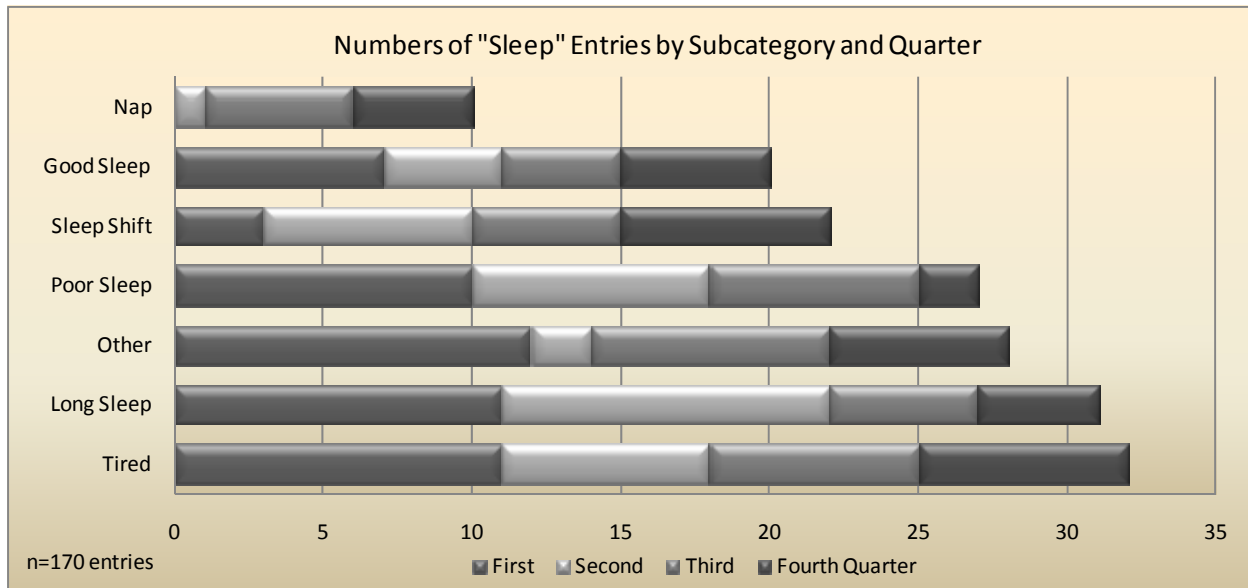
The teleconference was very interrogative and left me a little ticked off. I did not even bring it up with S until the next day, because I knew it would make him angry at the US side and I did not want to spoil his good mood on the eve of the weekend.

I like the incremental approach the Russians use for preparing for this sort of event; the Americans would assume that you'll do all your mental preparation in your spare time.

I was a bit upset today as I reviewed plans for the week and EVA prep. Turns out there are no PAO events after our EVA. I find this unacceptable and voiced my opinion. The response was that there are too many high priority items to be taken care of. I want the US taxpayers to know what we are doing up here and it only takes about 30 minutes of our time to do an event. I offered my weekends and personal time if that would help them out. We shall see.

The problem at NASA is that nobody can or will stand up to the safety organization. The safety folks seem to concentrate on minutia while neglecting big things. We need managers to override the safety organization or we will never get to Mars. The journey itself will be deemed to be too unsafe. Can you imagine Koroliev or Von Braun succeeding in this environment?

The week finished on a high note, I had our regular Astronaut office and Flight director's conferences yesterday, as well as the Program manager's conference today. In all three, we discussed my concerns about inefficient use of time onboard and the consequences to doing meaningful science and other work. All were very receptive, so I was satisfied with the meetings. I am sure that I am not the first crewmember to voice such sentiments. Time will tell whether or not things change. There's a lot of inertia at a large organization like NASA.



Few people know what it is really like to live and work in space, but we all are familiar with the performance-degrading effects of poor or insufficient sleep. Humans can endure many forms of deprivation and motivation can even counter the effects of fatigue, but only temporarily because the requirement is finite and deficits are cumulative. We all eventually succumb to the need for sleep. The numbers of journal entries about being tired and poor sleep recorded during the first quarters of ISS expeditions, and the numbers of entries about long sleep during the first and second quarters suggest that astronauts learn their limits of reasonable deprivation and develop effective strategies during the initial period; that is, they learn to sleep in space. The diminishing frequency of references to poor sleep supports this explanation. The subcategory labeled "Other" includes references to dreams, flashes caused by solar particles striking retinas, sleep interruptions, and sleeping location; some are simply statements that it is time for bed. Examples from the sub-categories follow.

It's late and I'm tired, but I want to get into some sort of routine doing this.

I am trying to get to bed to buy back some of the sleep deficit I'm building up.

I just need sleep.

I fell asleep while typing.

I feel pretty tired today. The fatigue is the result of getting only 6 hours of sleep most nights. The temptation to try to get a jump on tomorrow has been too great to ignore.

I was awakened in the middle of the night by the ground telling me to close the shutter on the lab window. It is beyond me why it couldn't wait until wake up time.

Very tired. Woke up at 2 am and couldn't get back to sleep. Finally fell asleep and overslept.

Half a day off today...I slept a solid NINE hours. I didn't know I could sleep that long!

I slept in this morning until 0900 and it really felt good. I was really exhausted last night (for no particular reason) and think I slept for about 10 hours. The alertness is much better today.

I slept until 10 am on Saturday, which is very unusual for me.

Really slept in this morning. Got up so close to exercise time that I could only drink a black coffee. Feel much more rested.

The morning started disastrously. I slept through two alarms, one set for 0600 and another a half-hour later to remind me to take some CEO pictures. My body apparently went on strike for better working conditions.

I slept poorly again last night.

I again woke up earlier than I wanted, not feeling quite rested but afraid to squander any time.

The time shift is starting to make the end of the day tough. We are pretty tired right now having shifted about 6 hours over the weekend.

We started sleep shifting back to the left about 8.5 hours. I chose not to take any Ambien because although we were scheduled to go to bed early, I was pretty tired and figured I wouldn't need it to fall asleep. I was correct, but failed to anticipate that I'd wake up a few hours into the sleep period and not be able to fall back asleep. I stayed awake for a couple of hours and was feeling rather anxious—not sure what about.

Slept great last night. Makes all the difference.

Got some good sleep last night, so maybe that will make today more interesting.

Since I haven't been sleeping well I decided to preemptively move my sleeping bag elsewhere where it might be cooler. I chose my familiar home of the airlock, but slept poorly there anyway.

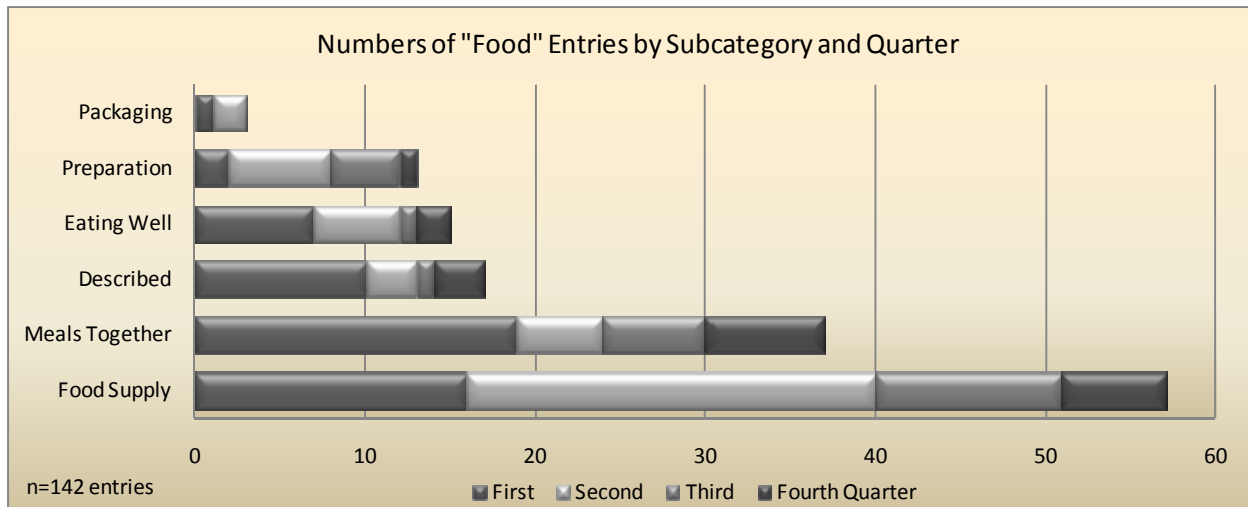
We are passing through the South Atlantic anomaly during our sleep and I have noticed a few more characteristic radiation streaks in my visual field as I drift off.

I feel that I'm slowly understanding how to better manage my time, but even tonight when I thought I had a good chance of being in bed by 2200, it's almost 2300 and I am not yet there.

I need to get more sleep tonight than the past few. I can feel the fatigue accumulating and it will be important to be rested for the undocking in a few days. For that reason I will close for now.



Dr. Joe Kerwin wearing electrodes in his *Skylab* sleep chamber, 1973.



Food assumes added importance when access to friends, family, leisure pursuits and other normal sources of gratification are denied. The importance of food during isolation and confinement is well-known to the managers of oil rigs, commercial ships, Antarctic research stations and nuclear submarines, all of whom serve large quantities and varieties of high-quality food daily. The polar explorers of the heroic era recognized the role that food can play in facilitating adjustment to confined and austere conditions, as did the managers of airlines until recently. Food is the quintessential habitability issue.⁸

References to the onboard supply of meal items compose the most-frequently reported subcategory of journal entries concerning food. Most within this subcategory were written in response to running low on supplies during a few of the increments and some are eerily reminiscent of Robert Falcon Scott's meticulous chronicling of his expedition's dwindling supplies while attempting to return from the South Pole. All of the participants described disappointment concerning the depletion of favored food and drink items, and many wrote about the joy of finding an item that had been believed to be long gone. The benefits of crews eating meals together also are reflected in the journals. A disproportionate number of entries from this major category are provided below to reinforce Fridtjof Nansen's admonition to be especially careful about the food.

We actually have a pretty wide assortment of food and it's not bad at all. One of my concerns was being able to put up with the food for six months. Although it's not quite home cooking, the folks in the food laboratories in Houston and in Moscow have done a pretty good job on the menu, providing us a wide assortment of quality food and drinks.

I really do wish for more American type breakfast food. The Russians eat a lot of cheese stuff, some of it quite good. I enjoy most of their food and am even trying new things that I didn't care for previously. I hope it doesn't get too "old" after several months!

Only now do we understand the depths of [a different previous crew's] plunder of our food! X took all of Y's canned fish, including those in his bonus containers! Fortunately, we have some left. We joked with them on a scheduled air/ground conference, but are a little sore about it.

I am still concerned about the food situation. How could the ground have miscalculated so badly? Not much we can do about it, but it is irritating.

We are getting tired of eating chicken all the time, but it will be OK.

I hate the idea of not having enough to eat in space. The data suggest that one is much better off eating a lot, in terms of keeping bone density up and overall health too.

⁸ For more on this topic see Chapter 10, "Food Preparation" in, Stuster, J. *Bold Endeavors: Lessons From Polar and Space Exploration*. US Naval Institute Press: Annapolis, MD, 1996.

Our food supply is in worse shape than we had believed. Projections now show us running out of main courses two weeks before Progress arrives. The projection is conservative, so I hope that we will not be eating crackers and water for two weeks. That would be like the stories of prison. So, we should not have complained about chicken, since that chicken may soon run out!

Food is still our biggest concern. We are out of side dishes, such as potatoes and vegetables. We still get some vegetables in the soups, but not much. We have packaged fruit left, so that's at least something. We still have eggs and bread, but don't know how much longer that will last.

The food situation is getting worse; we are definitely running out of things and are starting to resent the last crew for not telling the ground what was going on. We could have brought more food with us.

I've lost 4.5 pounds over the last two weeks and S has lost about 3.5. We are trying to make a joke of it, to keep a positive attitude.

The ground has now realized the dire food situation. I performed a detailed audit and sent the results down. For real food, I think we only have in the neighborhood of 1200 calories per day per person. Include all the sugar on board (candy, desserts, extra juices and sweetened drinks) and we have plenty of calories, but we don't plan on eating too many sweets.

I discovered extra main course rations in my bonus containers, so we enjoyed a dinner of ____ and were very happy. It is amazing how this seemingly small thing made our evening. On the ground, this food would not be considered particularly appetizing. However, take it away from us and it seems like the most delicious food in the world.

It is probably not a bad thing to lose a few pounds, but psychologically, it makes a big difference whether one is choosing to lose the weight or if one is being forced. We are able to remain in good spirits overall, with moments of anger and frustration at what [a previous crew] did to us.

The good news is that we have good food on board now. It makes such a huge difference in mental attitude. We should be fit and ready for the EVA.

We ran out of coffee with cream and sugar a couple of days ago and I really like my coffee in the morning. Then I enjoyed a small victory when I discovered the mother lode hidden in a CTB in the Node. I'm happy again.

Found out that the program wasn't planning to include salt in our food shipment. Not a pleasant surprise. I sent an email making it clear that we were not involved in that decision and were extremely displeased. Folks are trying to get some added to the Progress manifest.

The food is getting somewhat old to us. On paper we have quite a variety and it is not too bad actually, but I think it is starting to all look and taste the same. Perhaps we are just tired of eating out of a can or wrapper.

We sorted through and found all our favorites and saved them, pitching the jellied beef tongue we had in abundant quantities (because none of us will eat it).

I have had many programmatic fights with the Russians about the inequality of Russian/US foods (supposed to be 50/50). They have always had more Russian on board, using the rationale that people like Russian food better. That is bull ____.

I like writing this after lunch. A bag of tea slurping past my lips makes me relaxed and calm. I can even handle the news we just heard that all the food containers sent up on the Progress are not for us, but the next crew.

We opened new food containers yesterday, so every meal is like a fiesta, with lots of things to choose from and no reason to eat anything you don't like. When the cupboard starts getting bare, I start eating things like asparagus for breakfast and drinking ultra-sweet fruit drinks and all the things I put off until last. But in general, our food is quite good.

No one ever told me that there are practically no tortillas onboard, even though everyone knows they are incredibly popular for eating just about anything.

Everything is good health-wise and food-wise. One of the food containers we opened yesterday was actually intended for ____ and it had some good stuff in it that is absent from our menus, including some of my favorites.

Z flew into the Lab and tossed me a fresh apple soon after the Progress arrived. That was really great! It was a welcome change.

I'm trying to figure out the food situation, AGAIN. If the Unpack List is correct, we'll run out of some US food items well before E__ arrives. I don't understand why management doesn't put a higher priority on this.

The big decision for dinner last night was what we should eat with our onions! I am not sure why onion tastes so fabulous up here.

I was very happy the other day to reopen a bonus food container—one from which I thought I had pillaged all of the coffee—to find a cache of both espresso and lattes. I am now set for the rest of the mission (I had been rationing myself; having a latte only every other day and on off days mixing an espresso with an instant breakfast drink or, on one rare occasion, a cocoa).

Finally opened a food "kit," which is packed in a 0.5 CTB versus standard food containers. I had been told that a food kit has the equivalent of two food containers. Doesn't look like it to me. This kit ostensibly was "meats and entrees." Approximately 15% of the volume of the container was taken by coffee and tea. My estimate is that we'll go through this in 20 days instead of the promised 30. This whole food business just hasn't been done well.

Still chapped about the food. Not only are we short, what we have doesn't really support our menu selections. I simply don't understand.

We had a great dinner last night. Even X took a break from packing to enjoy the company and camaraderie. It was a testament to the unique bonds we all have from sharing the experience.

Last evening we had a great dinner with downlink video to the ground. I think it was a hit on the ground and we all had a great time around the table (mostly playing with the food).

Almost supper time! It's amazing how meals become the high points of the day sometimes.

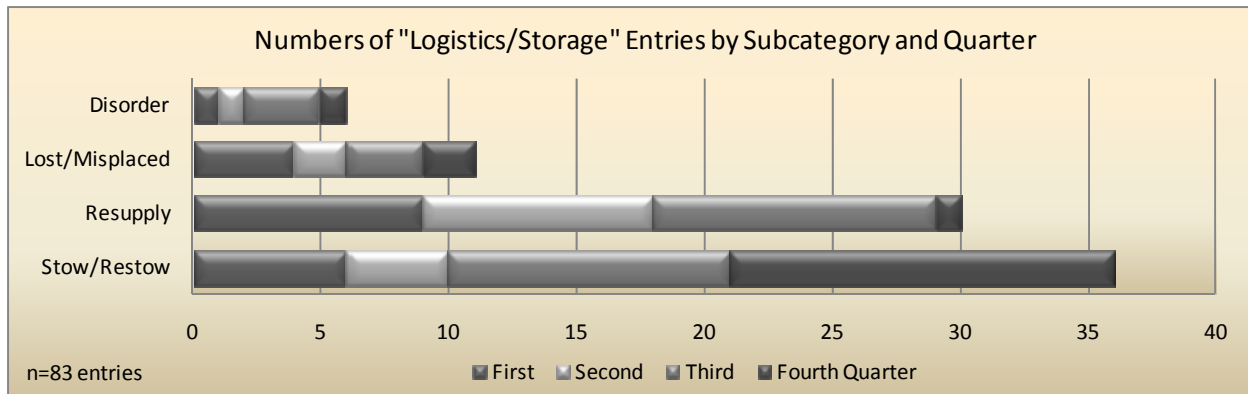
We ate together and talked and laughed. It was a good day for our crew.

The Russian stuff is a little greasy, but it is tasty. I like the fact that we hang out together and eat together. I think we are lucky in that regard. The Russians have that part down well.

It is time to put supper in the oven. I find that it makes a difference to spend a little extra time in preparing the meals to make them more enjoyable. Although there is only so much you can do with space food, a little effort goes a long way.

My favorite dish is ____ and I had been waiting for the day when we could open a new food container of main meat courses. I dug in with such great enthusiasm and was so disappointed that the container, which said it had 3 ____ in it, had none. The next container 10 days later also had none (but at least this one didn't show one on the list). We've run into several mislabeled containers since then. It can be disappointing.

One last funny story—during the first month of our stay, I noted that the labeling on two types of food packets were backwards: "Beef Tips with Mushrooms" was actually "Chicken Teriyaki" and vice-versa. I reported this to the food people and they thanked me for pointing out the labeling error. Today I wanted chicken teriyaki. So, I gambled that the labeling problem had not fixed for the new batch of food that came up recently, and selected "Beef Tips with Mushrooms." I was rewarded for not having overestimated NASA! The chicken was in the packages labeled beef.



Logistics and Storage emerged as a major category in response to the large numbers of entries referring to the tasks and problems associated with supplies. Only 83 entries received primary category assignments to Logistic/Storage, but the total of related entries is three times that number; several examples of entries with secondary assignments to Logistic/Storage have been reported in discussions of other major categories (e.g., Work, Food). An inverse relationship during fourth quarters between resupply concerns and stowing items in preparation for crew rotations is evident in the figure.

I tried to keep up by entering the items in the Inventory Management System. X is not too keen on that (most of the Russians seem not to be), but he does recognize its importance. I would say that the data base is 90 percent or more correct for the US segment; probably less than 50 percent for the Russian side. It's hard to be a perfectionist up here.

Finally got the EVA equipment restow sorted out. It was pretty confusing. I had been warned that you could get info from as many as 5 places for a single task. I think this was only 4, but it sure was confusing. Don't want to fuss at the ground about it.

Stowage is the biggest issue. I had some time today, so I helped with the ___ pack. Wow, what craziness. I think we did a good job keeping the situation happy and light, but I am sure it was frustrating for the folks on the ground. They want to give us a good product, but there is just some situational awareness that is missing—or some constraints that really seem crazy to us. But that is how it goes. W told me about this and I am starting to realize some of the frustration I saw in him before he left, particularly on the Russian side in regards to stowage. I really think either they don't get it or the cosmonauts don't want to play. There are bags behind all the panels with just stuff in them. It is rather humorous! It is really too difficult to get aggravated about.

Spent the entire morning unpacking. I am starting to get irritated at the stowage plan. Every time I unpack a bag, I have to stow the empty bag somewhere (they are only semi-collapsible). I am now getting overwhelmed by bags. The airlock is a disaster area; I have attempted to keep it orderly since I've been here, but it's simply swamped with the volume of stuff we've thrown into it. Every light is blocked, so working in there is like spelunking. I'm not sure where the ISS designers figured we were going to put all this stuff.

We made it though without a great deal of difficulty, although once again, the stowage onboard was a problem and the procedures were inadequate.

We're going to take our time on the unpacking, since everything we remove from the supply ship has to be accommodated somewhere on the station. We haven't found our care packages yet.

We've been unpacking the Progress. Found our personal items, the US food is once again stocked and we enjoyed some fresh fruit. The first thing I did was eat a grapefruit and it was very good.

It took all of the 25 minutes allocated to uncover the right panel (picture 20-30 food containers flying everywhere).

It looks like the US food is in good shape, but the Russian food is not quite what we expected. They sent us a bunch of crackers and cookies and drinks, even though we told them not to. I think we don't have enough cans of main courses. I have asked the ground to come up with guidelines on consumption rates of different categories of food.

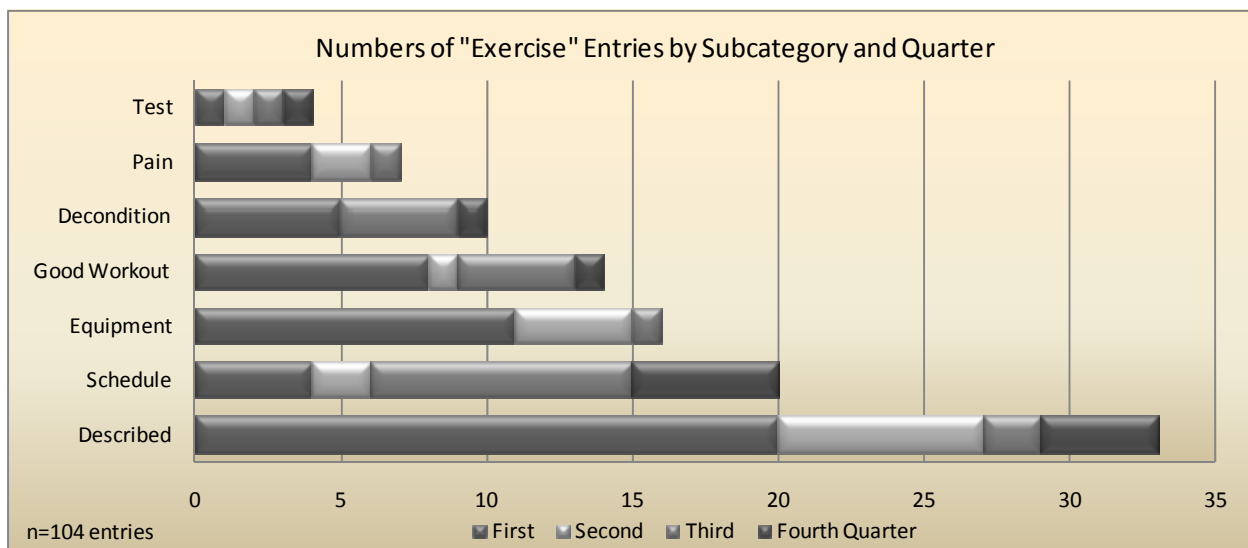
Really think our provisioning folks have set up a system that's convenient for them, not for us.

The stowage is completely disorganized and the stowage locations are notoriously unreliable.

I started encountering errors in the prepack list. That is slowing things down a lot.

This afternoon was spent with Progress unloading. The only thing I unloaded was a bag with office supplies. Hard to believe we send up one pencil at a time. There must be a better way.

One big victory on Saturday was that we finally located a ____ that has been lost for over a year. It's the size of a home water heater, so it's hard to imagine how it got lost, but we found it behind a seldom-opened panel. In fact, before the ground suggested that we look there, I never even realized it was a stowage space.



The largest subcategory of journal entries concerning exercise is composed primarily of declarative statements about having performed one or more forms of exercise; more than half of these entries were written during the first quarters of expeditions. The second most-frequently-assigned subcategory is composed primarily of complaints about exercise schedules; most of these entries were written during the third quarters. The next subcategory consists of entries that describe the exercise equipment, with most of these written during the first quarters, as might be expected. The remainder of the entries in this category range from references to the pleasure derived from a good workout to the pain derived from these activities. A few examples are provided below.

The rest of the morning was spent exercising.

Just finished running and will lift here soon.

I've been exercising a lot—about 2 hours every day.

Rode the bike, but decided to skip my weight workout for the first time in a month.

It's strange how that workout has become sort of sacred to me.

Exercise came late, which delayed lunch.

I have not exercised in 3 days, which is an indication of how far behind I feel we are getting.

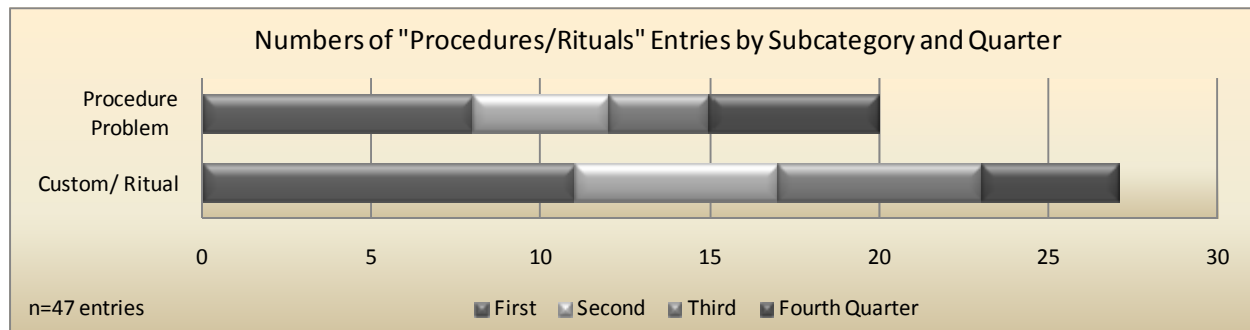
Wow, another slightly oversubscribed day. I am unimpressed with the scheduling process. Knowing how much I like running, I had IRED scheduled for the morning and CEVIS for the afternoon. I am convinced there are hidden scheduling constraints. It was so simple for me to just run in the morning and lift in the afternoon. Why can't they figure this out?

Today I ran on the treadmill for the first time. It worked pretty well. You have to wear a harness with a heavy bungee cord and an adjustable length set of hooks to adjust the load. The treadmill is stabilized by a gyro as well as mounted with vibration isolators (throw masses) that compensate for your bouncing around. The treadmill essentially tries to float and avoid passing the loads into the Station structure. The harness feels like you're wearing a heavy backpack, but I was able to run with it just fine. I was happy with myself today, because I've heard that it takes weeks (perhaps 6 weeks) to get comfortable with the treadmill—until then it is supposed to be torture. I didn't exactly run a marathon today, but it felt great—so I'm off to a good start with it.

It feels good to finally get to do more exercise on a regular basis.

Off to exercise... It was good to exercise and then get cleaned up. TVIS is difficult especially with the entire load on the shoulders.

I was tired at the end of the day and it was really good to get on the bike and work out. Put on music and enjoyed the ride.



This category consists of entries that describe customs and rituals associated with spaceflight and ISS operations, and entries that refer to problems with procedures. Examples follow.

The farewell ceremony yesterday was tough. X was feeling very emotional and so were Y and Z, as well. It got written up in one of the press articles. I think W thought we were nuts!

The change of command was awesome.

I rang them onboard with the ship's bell.

Our 100-day party was yesterday, and V and I phoned in to the bar and chatted with all the folks there. It sounded like everyone was enjoying the party. I received an email this morning showing scenes from the party. They had set up life-sized cardboard cutouts of W and me and the pictures showed us surrounded by adoring women. Very nice!

Last night, I remembered to write the poem US Navy tradition seems to expect of commanders on ships, at New Year. It delayed me going to bed an hour, which did not improve my attitude to the tradition, but I feel great now that it is behind me!

I found a few procedure problems already. I don't have much tolerance for that, and some procedures are written so poorly.

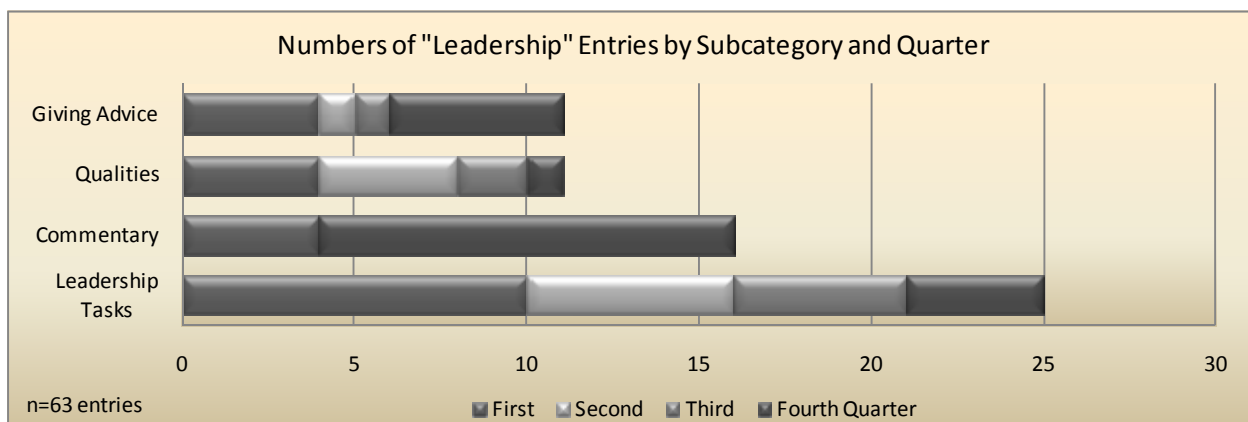
I don't like it when they uplink procedures with errors. I sometimes wonder what they do all day. They clearly aren't in the procedures along with the crew.

The ground team was working very hard to get the various updates incorporated into the procedures and training products on board for our use.

Uplink consisted primarily of the ground procedures, containing steps and commands that have no significance to me as a crewmember. Accompanying this esoteric procedure were pages of tiny images that, with no context, are useless.

The radiogram was pretty simple: remove the ___, disconnect the power cable, replace with a ___ and the new ___, connect the cable. Done. However, there was so much involved that wasn't taken into account in the procedure. I had to cut the cable out of a huge bundle of cables, the cable had a grounding wire of its own, the tool callouts weren't even close to that required, the bolts were installed backwards on one of the new ___, there was a bolt missing from another, the terminator on the grounding wire on the new cable was too small for the bolt that attaches it to go through, and more. It was overwhelmingly obvious that no one had looked at the procedure on any kind of flight-like mockup. It took me the three hours to install just one.

We discussed options and looked at the 5 word description of the task (a couple of times) and decided I needed to remove the ___ and clean under there. After chasing down the right tools, I took one ___ off and it was also clean. I think I know why there is a cosmonaut union now!



All of the entries assigned to the Leadership category were references to leadership qualities or descriptions of leadership tasks. Some of the entries were written by leaders and others were written about leaders. The content and tone of the entries suggest that the expedition commanders were conscientious and that their efforts were appreciated. Examples follow.

I need to get X into the USOS more. He really doesn't know what's here and how to use the equipment.

I got a little terse with Y because he's not reading/following US procedures. He goes through Russian procedures with painful thoroughness, but just wings it with US procedures.

I just think as the commander of this little ship the priority is to see how the other folks are doing.

The CDR has been helpful, involving me where possible and acknowledging my presence before docking.

I am setting the tone for us, staying upbeat and staying nice with the ground teams. They are well-intentioned and do their best. We must help them with what we need.

He tries to have us eat our meals together as much as possible. It doesn't always work out, but usually we do (not counting breakfast).

One of my goals was to exercise positive leadership, both for the crew and for the ground teams. I think I accomplished that.

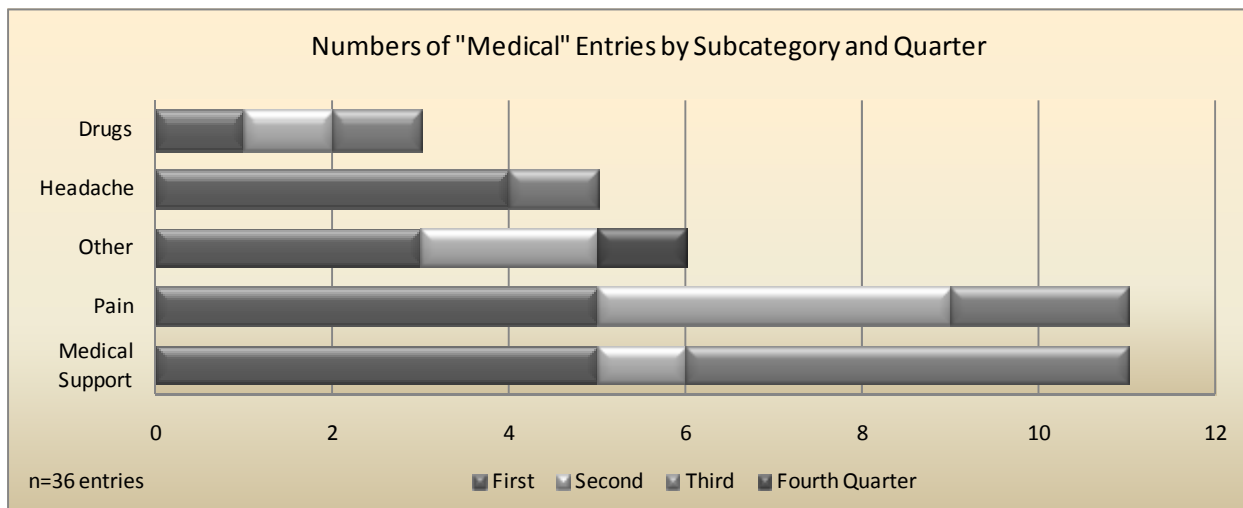
I must make sure that Z gets to exercise too. This is an important week to stay in shape!

I need to recommit myself to being mentor, versus driver.

He's been a great commander and I really appreciate his ability to command only as needed. He completely leaves me in charge of everything that's not Russian and has never once tried to dictate how or what should be done anywhere other than in the Russian segment.

I am a bit angry today. It appears that my Commander is off making agreements that affect me without consulting me. I do not necessarily disagree to do the work, but I definitely disagree with his making agreements without even discussing it with me. That is NOT the sign of a good commander. I am ready to be going home. The stress is getting to me a bit.

I put him in charge of housekeeping discipline, because he was becoming irritated by the disorder created mostly by Q, and all the other activities around him. I did this with the whole crew present and said he had the right to scold anybody, as it was in his interest. After that, he started to be more tolerant, and by the time we got to the ceremony he was joking kindly about the bad habits and already Q and Z especially, were doing better in keeping themselves in order.



The entries assigned to the medical category are primarily descriptions of the normal aches and pains that result from heavy exercise, but also include the effects of micro-gravity, such as headaches (from the lack of convection and/or insufficient CO₂ scrubbing) and skin and nerve irritation from working in EVA suits. A few examples are provided below.

So, I finally called the doc today to discuss it. I am thinking it will just get better with time.

We had a medical CPR OBT. It went well.

Healthwise I'm feeling fine—occasionally I've had headaches brought on by CO₂.

I have been waking up with headaches. It seems to go away when I take some Sudafed, which definitely clears up my stuffy head. I am feeling much better right now. It also helps when I eat something.

One stressor today was that my left forearm is acting up a bit. It has bothered me for a couple of nights, and I am thinking I must have just strained it a bit flying around and catching on a handrail or something.

I ended up with some nerve irritation due to the gloves apparently. It is a little better today. I was pretty exhausted mentally after the EVA, but felt pretty good physically overall. I could certainly tell toward the end that I was ready to come inside.

I got a little nervous today. I am worried about getting sick up here. Just don't have time for that right now--maybe later in the increment, but not now.



The *Fram* in the Ice, by William Gilkerson

Fridtjof Nansen reclined in his snug cabin onboard the *Fram* reading an account of Elisha Kent Kane's disastrous expedition in search of Sir John Franklin in 1852. The temperature outside was -36 degrees F (-38 degrees C) and the sturdy ship and polar icecap on which it was cradled were shrouded in the perpetual darkness of the Arctic winter. The *Fram* had been locked in the ice for six months, but Nansen and the other 13 members of the Norwegian Polar Expedition were enjoying the experience and feeling guilty about their comfortable conditions while loved ones worried about them at home. Nansen reached for his journal and wrote:

Thursday 28 December 1893

I am almost ashamed of the life we lead, with none of those darkly painted sufferings of the long winter night which are indispensable to a properly exciting Arctic expedition. We shall have nothing to write about when we get home. I may say the same of my comrades as I have said for myself; they all look healthy, fat, in good condition; none of the traditional pale, hollow faces; no low spirits—any one hearing the laughter that goes on in the saloon, the fall of greasy cards, etc., would be in no doubt of this. But how, indeed, should there be any illness? With the best of food of every kind, as much of it as we want, and constant variety, so that even the most fastidious cannot tire of it, good shelter, good clothing, good ventilation, exercise in the open air *ad libitum*, no over-exertion in the way of work, instructive and amusing books of every kind, relaxation in the shape of cards, chess, dominoes, halma, music, and story-telling—how should anyone be ill? Every now and then I hear remarks expressive of perfect satisfaction with the life.⁹

⁹ Nansen, Fridtjof. *Farthest North*. Volume 1, New York: Harper & Brothers, 1897 (pages 354-356).

NET POSITIVITY/NEGATIVITY

It was described previously that each journal entry was assigned a code to indicate whether the statement was positive, negative, or neutral in its tone or content and that a metric called Net Positivity/Negativity (NPN) was derived by subtracting the proportion of negative entries from the proportion of positive entries.¹⁰ This metric was calculated for all primary category assignments by quarter for each expedition. Four sets of NPN analyses were performed: 1) By category with data from all journals combined; 2) By journal with data from all categories combined; 3) Adjustment entries only by journal; and 4) Comparisons of subgroups within the sample. The results of these analyses are presented in four sets of figures in the following pages. All figures use the same -1.0 to +1.0 scale to facilitate comparisons.

NPN analyses were conducted to test hypotheses concerning a “third quarter phenomenon,” a decline in affect, general attitude, or “morale” during the third quarters of missions, regardless of duration (suggested by anecdotal accounts and evidence from the previous content analysis of expedition journals). Analyses also were performed by dividing the journals into six chronological segments (the rough equivalents of months), but no patterns of NPN were evident. More information about the third quarter phenomenon is presented in Appendix B.

NPN BY CATEGORY: ALL JOURNALS COMBINED

The first set of figures illustrates the results of the NPN analyses by category with the primary assignments from all 10 journals combined for each category. These figures are presented on the following two consecutive pages, arranged in descending order of the number of category assignments for each of the top 18 of 24 categories; categories to which no entries were assigned during one or more quarter are not presented. The final figure in the set shows NPN by quarter with data from all categories and all journals combined (i.e., all 4,215 entries). The combined figure and eight of the category figures show declines in average NPN during the third quarter.

NPN BY JOURNAL: ALL CATEGORIES COMBINED

The second set consists of 10 figures, one for each of the journals, and illustrates NPN by quarter for all of the categories combined. Subjects were assigned number codes using a random number generator and the order of the expeditions was scrambled to prevent identification of study participants. Six of the 10 figures show declines in average NPN during the third quarter (i.e., all categories combined).

NPN BY JOURNAL: ADJUSTMENT ENTRIES ONLY

The third set also consists of 10 figures, one for each of the journals, but illustrates NPN by quarter for the entries assigned to the Adjustment category only. This analysis focuses exclusively on entries concerning adjustment to life onboard the ISS and was performed because the Adjustment category most closely reflects what might be characterized as individual attitude or morale. Nine of the 10 figures show a decline in NPN during the third quarters of the expeditions on this measure. The one exception (Subject 71) exhibited the lowest individual NPN value of the study during the second quarter. It also is noteworthy that a third quarter decline in Adjustment NPN was found for Subject 24, whose combined measure of NPN showed a linear, positive progression and for Subject 28, whose combined NPN increased substantially during the third quarter and was the only one to decline during the fourth quarter.

NPN COMPARISONS BY SUBSET WITHIN THE SAMPLE

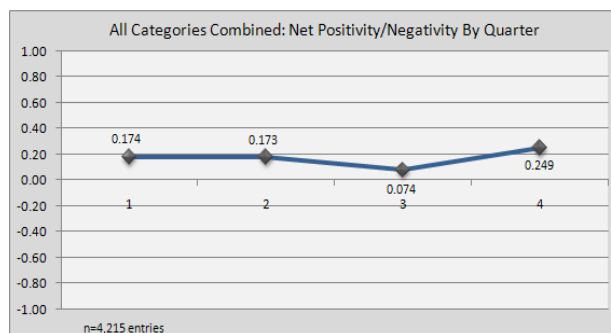
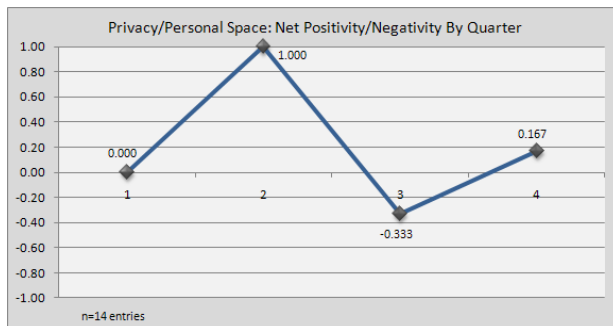
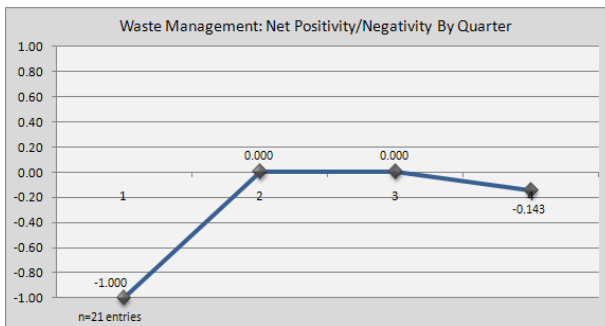
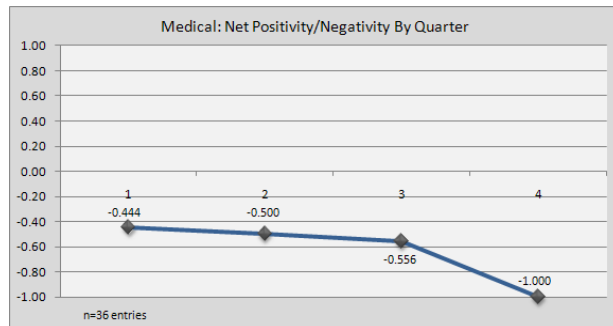
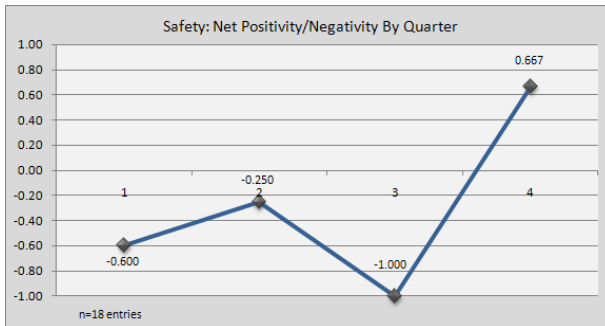
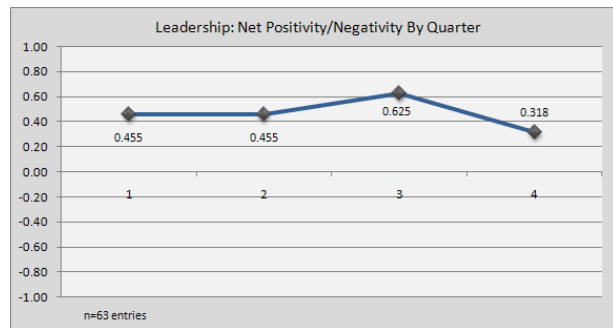
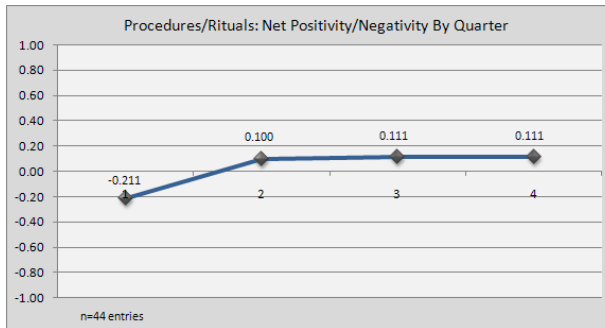
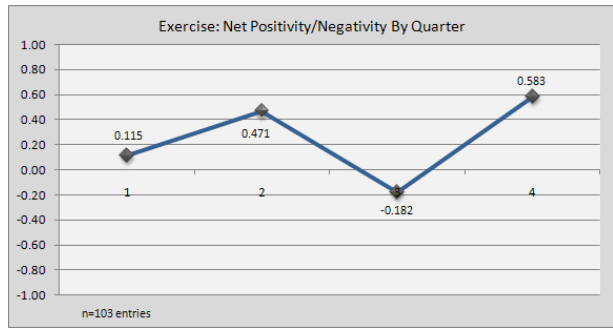
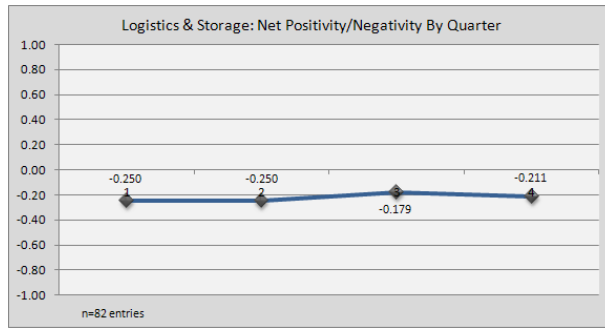
The final set of four figures illustrates the results of comparisons of NPN Adjustment values between subsets within the 10-astronaut sample: Commanders vs. Flight Engineers/Sciences Officers; Men vs. Women; and Two-Person vs. Multi-Person Crews (two versions of the figure). The latter subset consists primarily of three-person crews, but with considerable overlap of visitors and replacement personnel. Of the six subsets compared, only journals from multi-person crews failed to exhibit the third quarter decline in Adjustment. However, a third quarter decline is evident when data from the journal with extreme second quarter negativity, described previously, is removed from the analysis.

¹⁰ Proportions were used in the NPN analyses to control for differences in the numbers of entries written by the astronauts (i.e., to give equal weight to each of the 10 journals).

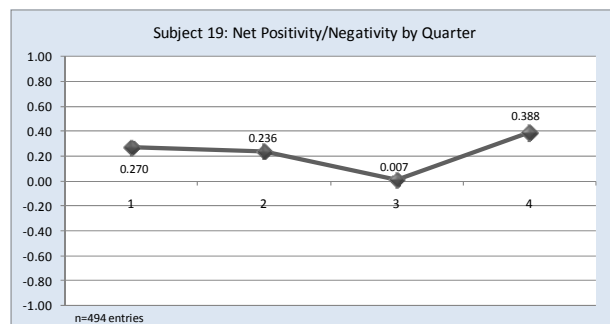
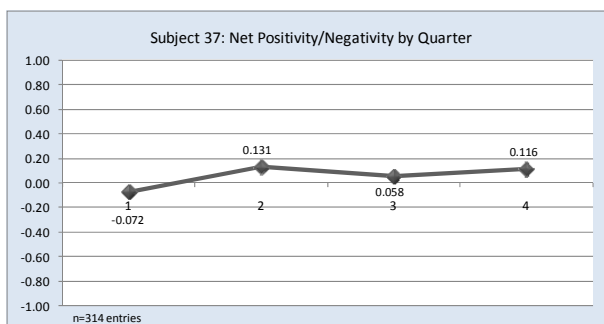
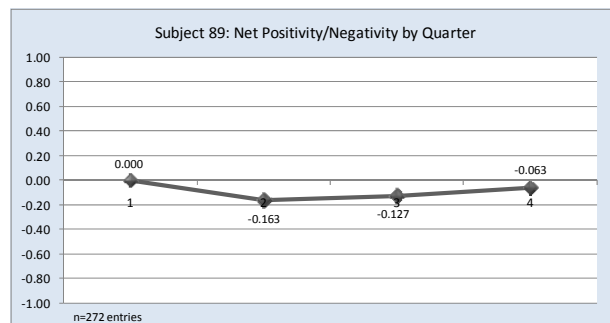
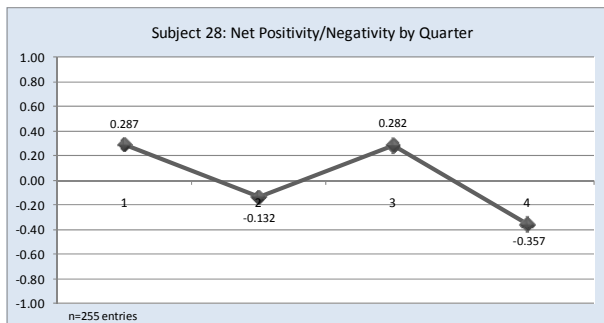
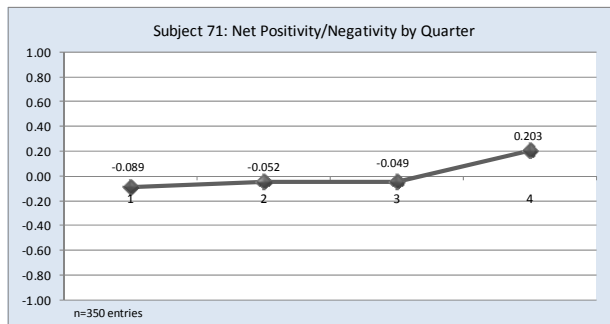
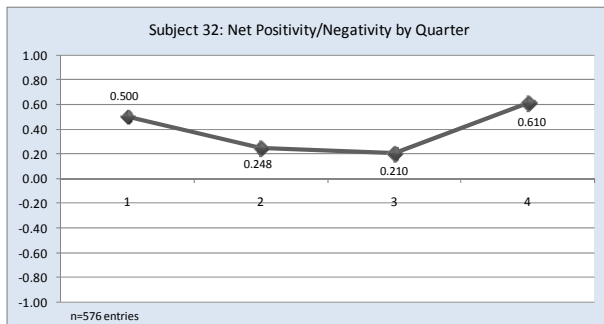
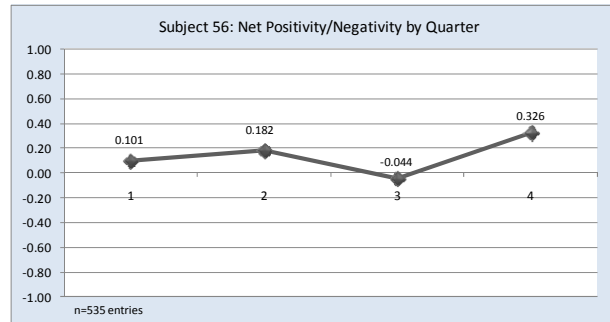
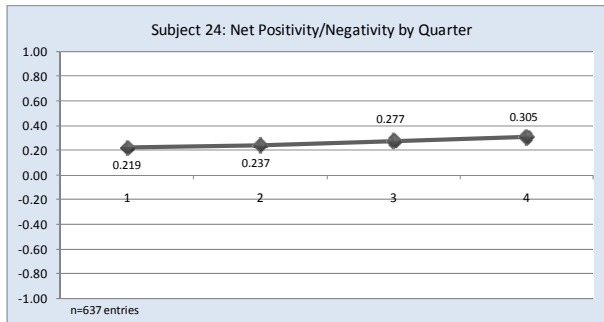
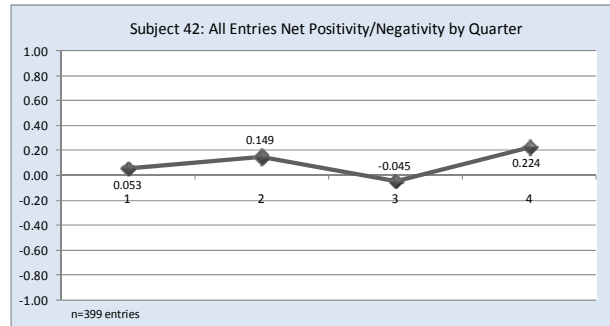
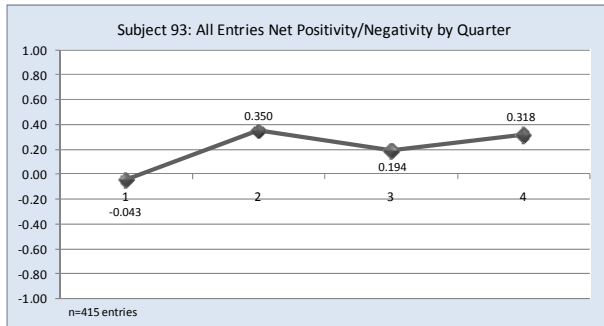
Net Positivity/Negativity by Quarter: All Journals Combined



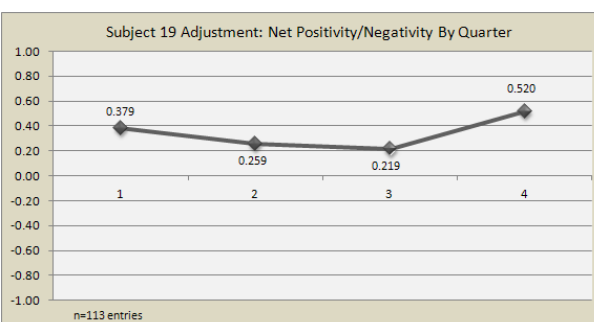
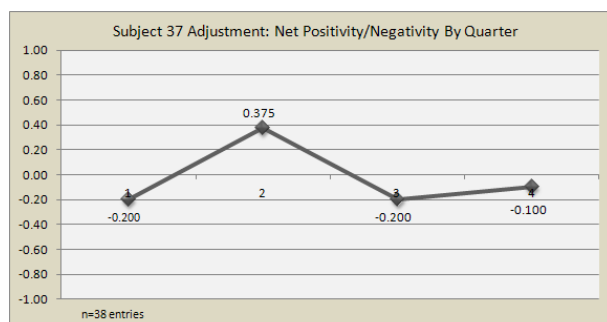
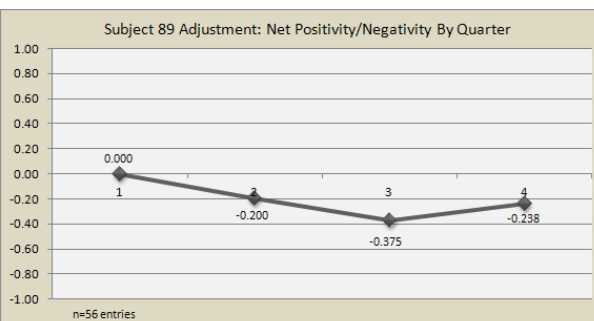
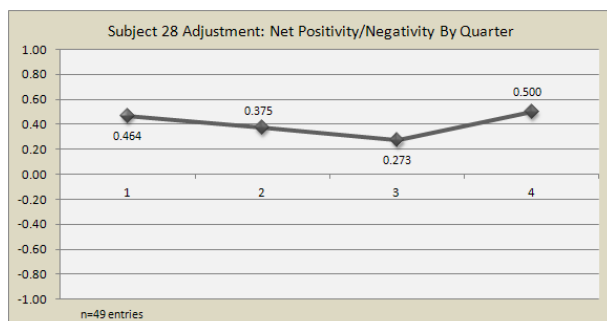
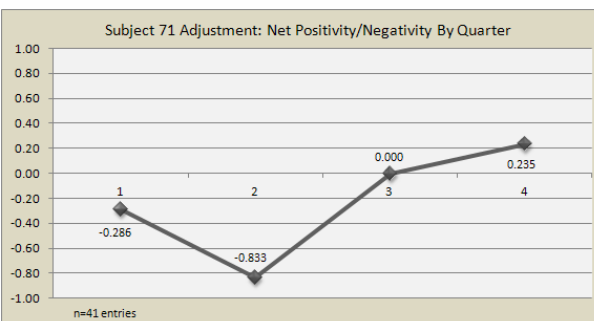
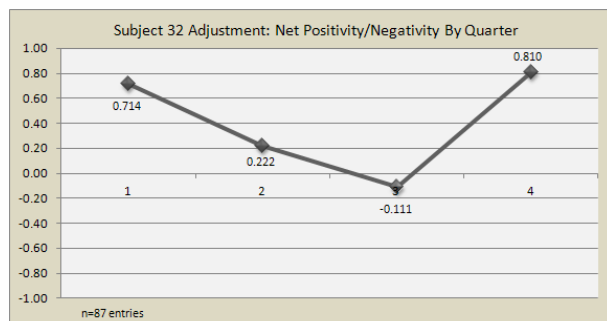
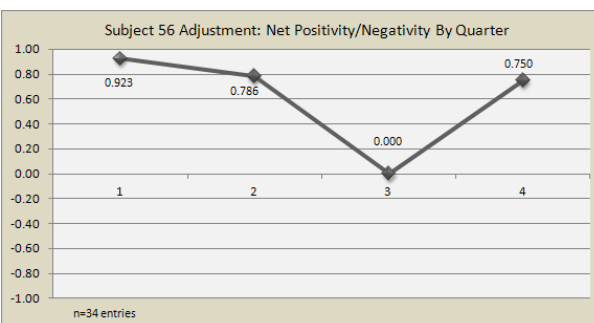
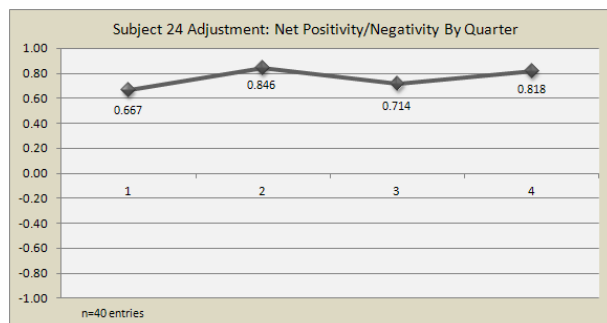
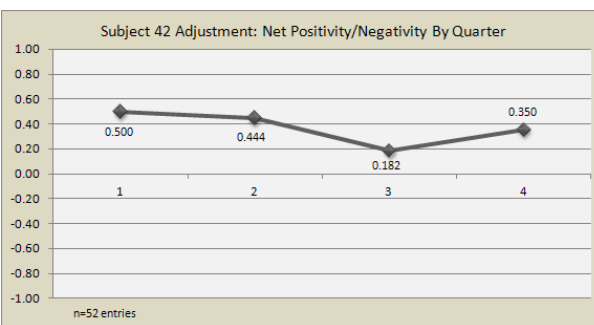
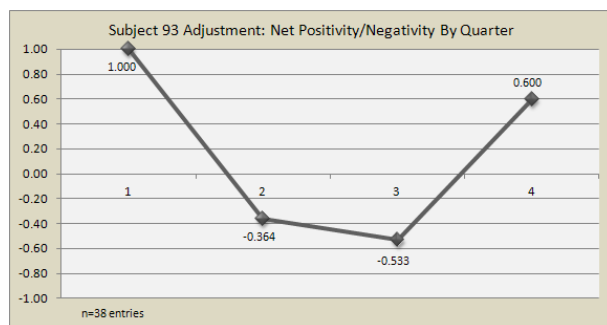
Net Positivity/Negativity by Quarter: All Journals Combined (Continued)



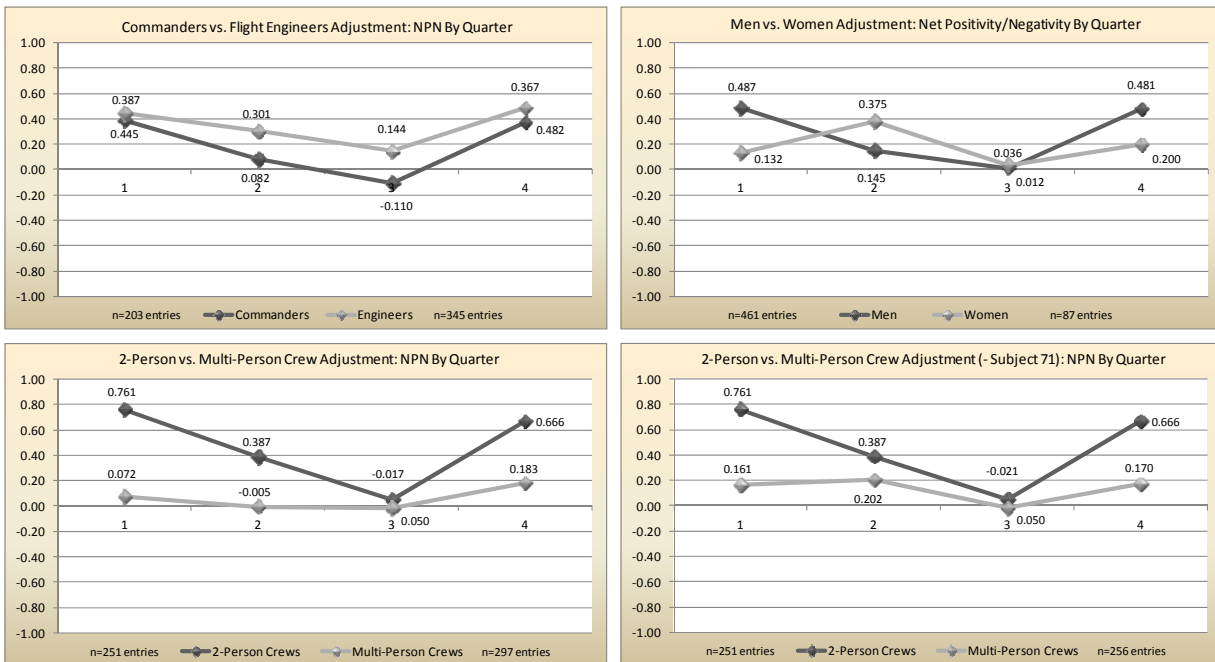
Net Positivity/Negativity by Quarter for Each Journal: All Categories Combined



Net Positivity/Negativity by Quarter for Each Journal: Adjustment Entries Only

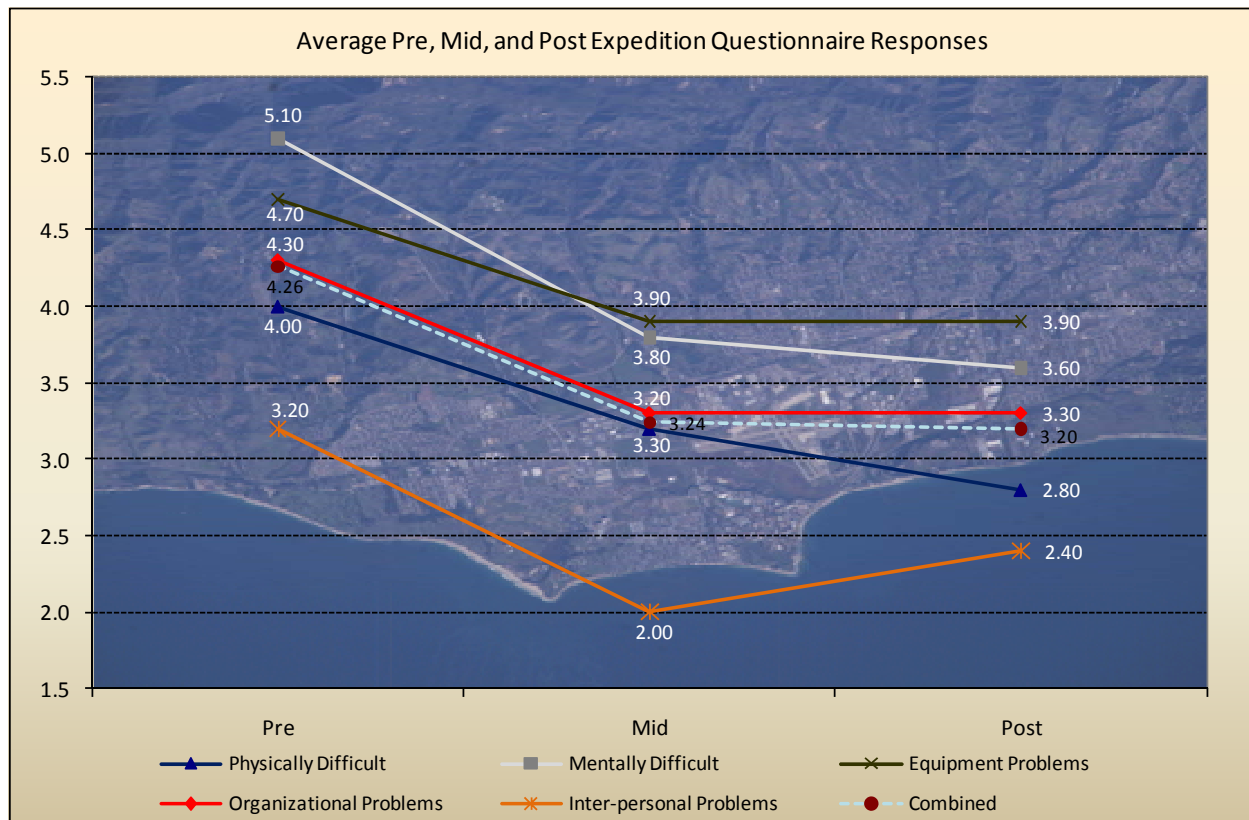


Net Positivity/Negativity by Quarter Comparisons: Adjustment Entries Only



QUESTIONNAIRE RESULTS

Results of the five scaled questions on the pre-, mid-, and post-expedition questionnaires are presented in the following figure. All mid-mission values are substantially lower than pre-launch estimates. Estimates of physical and mental difficulty are lower still during the second halves, while interpersonal problems increase. Overall, fewer problems were experienced than astronauts expected would occur.



IMPLICATIONS

At the time of this writing, approximately 235 people have been onboard the International Space Station since the first components were delivered to orbit in 1998, which is nearly half of all people who have made it to low Earth orbit, or beyond. More than sixty Americans, Russians, Europeans, Canadians, and Japanese have served as crew during two dozen ISS “increments” since Bill Shepherd rang a ship’s bell to commence Expedition 1 in October 2000. Several astronauts and cosmonauts already have returned for a second six-month tour of duty.

I was referring to the current period when I wrote in a 1984 report that astronauts would perform admirably even under extremely austere conditions if they were among the first crews of a space station or interplanetary craft; however, our research and development efforts should be directed toward the design of equipment and procedures that are not only tolerable, but conducive to work during *routine* operations.¹¹ Our word “routine” is derived from the French for a customary path. Life onboard the ISS has become routine and low Earth orbit a well-traveled highway during the station’s first decade.

It is clear from the journal entries analyzed during the current study that conditions onboard the ISS are far better than tolerable, but short of what is necessary to support optimum human performance for sustained periods of routine operations. Crews have performed admirably, as expected, and the journals contain many positive statements about living and working in space. However, the tone and content of some entries describe serious problems and convey levels of frustration and annoyance that could increase now that ISS operations have become routine.

The most salient implications of study results are presented below in sections devoted to the category, subcategory, and Net Positivity/Negativity analyses, followed by a discussion of questionnaire results. The report concludes with recommendations and a final note.

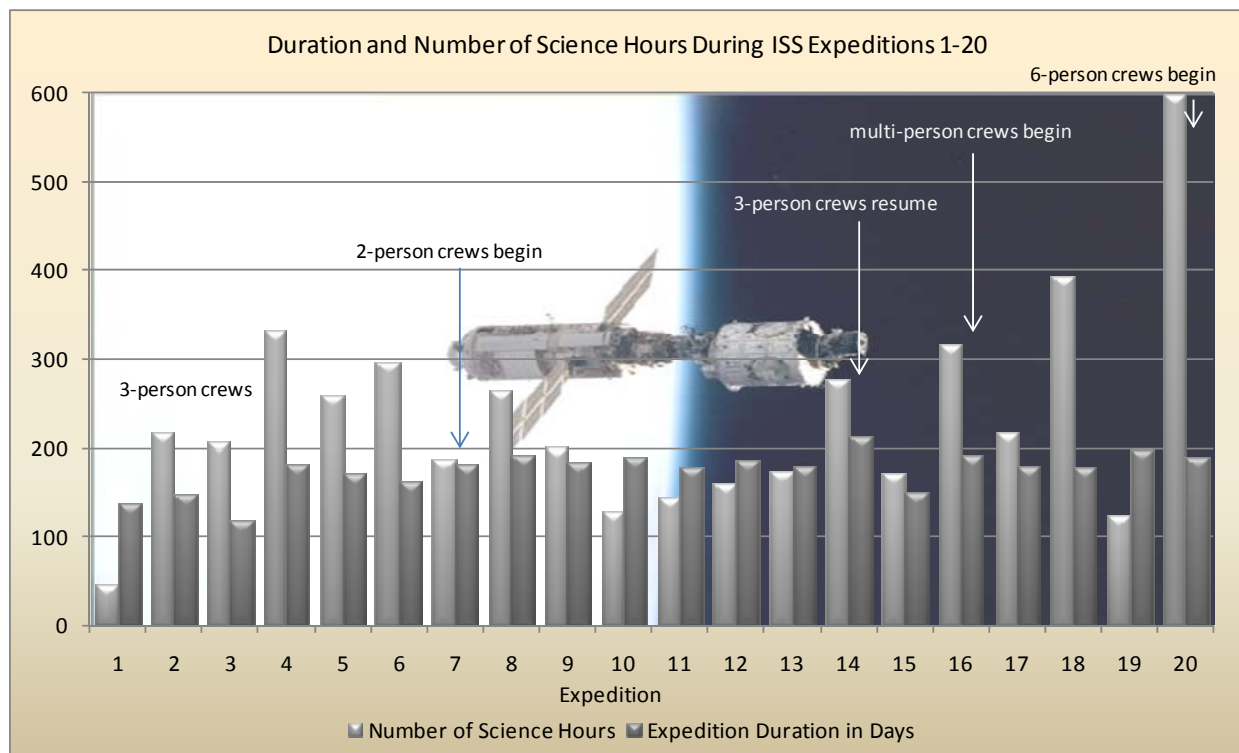
IMPLICATIONS OF THE CATEGORY ANALYSIS

The top four behavioral categories, Work, Outside Communications, Adjustment, and Group Interaction, received 59 percent of all primary, secondary, and tertiary category assignments of journal entries. Adding Recreation/Leisure, Equipment, Event, Organization/Management, Sleep, and Food to form a list of the top 10 categories accounts for 88 percent of all category assignments. The remaining 14 categories of behavioral issues are relatively unimportant, according to the assumptions of the study described in the Introduction to this report. Some of the issues considered by behavioral scientists to be very important received too few category assignments to be included in the presentation of results, such as Internal Communications, Habitat Aesthetics, and Privacy/Personal Space. Each of these three categories has been the subject of study and passionate debate, but combined they represent less than one percent of all journal entries in the database. Why might this be?

It is possible that these issues were addressed sufficiently by design of equipment and procedures to mitigate legitimate concerns, but it is equally likely that key factors have not yet conspired to elevate their importance. No one would deny the criticality of maintaining the proper mixture of gasses in the ISS to sustain human life, even though CO₂ levels, out-gassing, and leaks were mentioned in only a few journal entries. The number of references means that the life support system has functioned well, not that it is unimportant. The same probably is true for some of the infrequently mentioned behavioral issues. However, component failure, human error, or other perturbations could alter the balance and promote a previously low-priority issue to critical status.

¹¹ Stuster, J. *Space Station Habitability Recommendations Based on a Systematic Comparative Analysis of Analogous Conditions*, Moffett Field, CA: Ames Research Center. NASA Contractor Report No. 3943, 1986 (originally published as an Anacapa Sciences, Inc., Technical Report in December 1984).

Even changes implemented to improve conditions could have unintended, negative consequences. For example, the shifts to three-person crews with Expedition 14, to multi-person crews with Expedition 16, and to permanent six-person crews with Expedition 20 have permitted greater distribution of the tedious inventories and logistics tasks that seemed to dominate crew time during earlier increments. Larger crews also have resulted in greater science productivity, as illustrated by the following figure. However, the doubling of crew size inevitably has had a cascading series of negative effects, such as increased competition for exercise equipment, loss of privacy, and more opportunities for interpersonal conflict, to name a few. The latter effect probably contributed to the substantially lower NPN Adjustment values of multi-person crews, which were compared to NPN values of two-person crews in a previous figure (i.e., average NPNs of 0.128 vs. 0.466); in addition, 68 percent of the entries assigned to Group Interaction's Conflict/Disagreement subcategory were from the journals of multi-person crew members.



The effects of crew size on privacy and personal space cannot be fully evaluated with the current journals data, as all subjects participated prior to the introduction of permanent, six-person crews. The 10 astronaut journals contained only 36 entries concerning privacy and personal space—too few to even justify inclusion in the subcategory analysis. If privacy and territoriality are important to remote duty crews, why were these issues ranked so low in the (previous) French Diaries and (current) Journals studies? The leaders and physicians at the French research stations were the only members of their expeditions to have private quarters, to which they retreated frequently for respite from the stations' crowded conditions. Similarly, most of the astronauts' entries on this topic described having entire modules of the station to themselves for working and sleeping. Privacy/Personal Space was a non-issue for the participants of both studies, but that is rare in isolation and confinement and probably has changed onboard the ISS since the conclusion of the study, as suggested by the following entries. The first was written during a two-person expedition and the second pair during periods of transition to new crews.

During the light days, we arranged things in the station to our liking. I moved into the sleep station in the US Lab. It's much quieter inside and it is nice to have a closed-off, private space.

Whereas the Station with three people is a very quiet place, it is just bustling with six. There seems to be a body sleeping in every module. / It is more crowded now and I have to share my living space, which has not been much fun so far.

IMPLICATIONS OF THE SUBCATEGORY ANALYSIS

Ten astronauts wrote more than 4,200 separate journal entries, which were assigned to 24 major categories of issues with behavioral implications; 15 of those categories received sufficient numbers of assignments to be included in the subcategory analysis, which further divided the entries into 108 “themes” or subcategories based on similarity of topic according to the established coding rules. Many examples of journal entries that address the subcategories were included in this report to illustrate results of the analysis. More excerpts from the journals were included than originally intended because the astronauts wrote eloquently and candidly about their experiences and observations, and their own words are far more credible than an investigator’s summary.

The primary implications of the subcategory analysis are presented below and additional implications are discussed among the recommendations based on study results, which appear later in this report.

SCHEDULES AND TIME-RELATED STRESS

The main theme to emerge from the subcategory analysis concerns the overriding pressure of work schedules on crew personnel, which is caused largely by unrealistic time estimates made by those developing procedures and the mission planners who prepare the timelines that schedule nearly every minute that an astronaut spends on the ISS. Many jobs create time-related stress for the incumbents, from assembly-line workers to corporate and government engineers, scientists, and managers. Stress of this type is tolerable when experienced occasionally, but it can quickly become dangerously intolerable when a job involves a relentless stream of scheduled deadlines with insufficient time allotted to perform the tasks. The usual consequences of this condition are fatigue, low morale, interpersonal problems, and a propensity for error. The crew of *Skylab 4* also experienced time-related stress during their 84-day mission in 1973, as described by mission commander, Gerald Carr:

Everything was done sequentially on a very tight schedule. We were all so success-oriented and job-oriented that “following the carrot” got us in trouble, because if you make a mistake it is hard to go back and do the task over again. If you do, you get farther behind, the work keeps piling up, and you finish the day frustrated because you didn’t accomplish all that had been scheduled. There is going to be a morale effect because of all that pressure and the fact that you are not doing what you set out to do. There was no slack in the schedule; it only made the situation worse.¹²

Every tenth day was supposed to be a day of rest for the *Skylab* crew, but they sacrificed their first three days off in an attempt to catch up to the schedule. When mission controllers suggested that they work through their fourth assigned rest day, Colonel Carr’s response was, “No, we had better not work today; we had better get some rest.” The crew took their scheduled day off, which was widely and incorrectly described as a mutiny in space. It was, in fact, a triumph of reason and leadership over unrealistic scheduling demands. NASA learned about the importance of providing off-duty time for crew from this incident, which also led to removing all tasks from the schedule that were not dependent on the station’s orbit and placing them on a “task list.” Despite these lessons and decades of subsequent space operations experience, the agency persists in scheduling insufficient time for the performance of many tasks. The following entries from the Journals database echo the *Skylab 4* commander’s words.

The most significant stress factor so far is that everything on the schedule takes longer than planned. So I’m always behind. There are all kinds of reasons ranging from my own speed to not finding something where it is supposed to be. But the bottom line is that running behind schedule all day is stressful.

¹² Carr, G. Untitled presentation. In, Behavioral Issues Associated with Isolation and Confinement: A Panel Discussion Conducted at the Tenth Psychology in the DoD Symposium, J. Stuster, chair and editor. US Air Force Academy, Colorado Springs, CO, 17 April 1986.

We are, by nature and by training, performance and goal-oriented. We tend to feel bad about ourselves if we do not complete the plan. I am aware of this and have consciously tried to get perspective on this and not feel that I must complete all tasks and in the given time. However, I think there is an underlying frustration that builds when I do not complete everything on time.

TEDIOUS AND FRUSTRATING WORK / PROCEDURE PROBLEMS

The shift to larger crews has provided opportunities for schedulers to distribute the tedious tasks. Sharing housekeeping chores and unpleasant work equally is a tradition of polar explorers and the practice would reduce the levels of frustration experienced by ISS crew. The following journal entry from a member of a multi-person crew suggests that this is occurring already.

Teamwork can now suddenly be part of the approach to the entire day. This is a huge difference, which enables synergy that makes it possible to get more than twice the work done.

Only a portion of the astronauts' criticism was directed at the tasks. Although few will derive the satisfaction they need to remain motivated by counting light bulbs, underwear, or food containers, the astronauts recognize that certain menial tasks are necessary. The majority of the most-critical journal entries concerned the procedures that astronauts are directed to follow when performing the tasks. Adding people to the crew increases the station's capacity for work, but it also increases opportunities for ill-conceived and poorly-written procedures to annoy more crew. Several examples of procedure problems were included in the presentation of results and two more are provided below to suggest that all procedures receive thorough reviews periodically as part of an on-going quality control effort.

The procedure wasn't too bad until we got to the point where I was instructed to put a piece of tape over the _____. I searched high and low to find this _____, which turned out to be labeled something else. Do you get the picture about how stupid some of this is and how aggravating it can be?

I am frustrated that words used to describe items in procedures are not the same as the words on the equipment. I attribute this to laziness. We don't go back and review procedures to see how they may be updated to better serve the crew.

TRIVIAL ISSUES ARE EXAGGERATED

The exaggeration of trivial issues is a well-known principle of life in isolation and confinement. Minor annoyances, differences of opinion, and perceived transgressions that would be inconsequential under normal conditions can be magnified by isolated and confined personnel into issues of monumental importance. This tendency might even be greater for astronauts than for most remote duty personnel, because as a group they are the epitome of high achievers. The astronauts who participated in this study possess enormous capacities for work, but this trait often is accompanied by low tolerance for poor performance by others. The astronauts largely refrained from voicing their disappointments to the ground, but many of their journal entries expressed the sentiment illustrated by the following examples.

I am not looking forward to this week. I will have more tedium, starting with the final battery search. If this battery is so important, why didn't the ground do their homework to begin with and have me separate it months ago when the items were gathered, rather than have me search through the trash now?

One of my frustrations up here is that we constantly have to redo work. For example, X changed a cable today that I had installed about a month ago. Why didn't the ground have me install the correct cable at that time?

Astronauts and ground personnel realize the importance of maintaining pleasant relations and some probably are aware that isolation and confinement can influence behavior in predictable ways, such as the exaggeration of trivial issues. The pattern of “praise inflation,” described previously, appears to be a response to this understanding. Some astronauts crave recognition and most require frequent reinforcement to sustain their characteristically high levels of motivation. However, heaping disingenuous praise on them does not compensate for failing to correct inadequate procedures or asking the astronauts to fill holes they previously had been directed to dig. And, it is unrealistic for ground personnel to expect praise from space unless their performance is exceptional.

The best ways for ground personnel to maintain pleasant relations with on-orbit crew is to support their work with accurate and clearly written procedures, schedule sufficient time for task performance, respond promptly to requests, and avoid creating annoyances that could be exaggerated.¹³ Most important, everyone involved in human space operations should recognize and acknowledge the fact that only the remote duty personnel truly understand the conditions under which they live and work. This issue is not unique to space operations. Words similar to the following journal entry have been uttered about every remote duty operation since humans set up the first branch cave in a new area.

They can't imagine what it's like and what we have to deal with every day to make things work.
It's not their fault, but they can't see it from our perspective.

ADJUSTMENT TO THE CONDITIONS

Providing an appropriate habitat and meaningful work to a carefully-selected and well-trained crew can reduce the stress that accompanies life in isolation and confinement and thereby contribute to the likelihood of a successful mission.¹⁴ However, it is not possible to eliminate all sources of stress or the possibility that conditions might change and allow previously-addressed problems to emerge. Stress is cumulative if not mitigated in some manner and individuals respond differently to chronically stressful conditions. Most develop constructive coping methods, such as exercise, devotion to work, engaging in a personally gratifying activity, or commiserating with a comrade. Others respond with poor sleep, physical problems, degraded task performance (errors, omissions), irritability, withdrawal from social contact, or more serious behavioral aberrations.¹⁵

The results of the subcategory analysis were reviewed again to identify astronauts' explicit references to activities or factors that contributed to their adjustment. The review found the leading contributor to be what has been described in this report as “meaningful work,” which includes extravehicular activity (i.e., EVA), science experiments, Earth photography, and construction/installation; study participants also reported deriving satisfaction from completing almost any task within the allotted time. Additional contributors to personal adjustment identified by the review are: the IP phone (and email); Psychological Support activities (e.g., teleconferences with family, crew discretionary events); onboard celebrations (e.g., holidays, birthdays, milestones); meals and movie nights together; and personal projects (e.g., Earth photography, HAM radio contacts, engagement with ground personnel such as trivia contests and the chess tournament). Also, nearly all study participants mentioned writing in their personal journals as an activity that helped them adjust to living and working on the ISS.

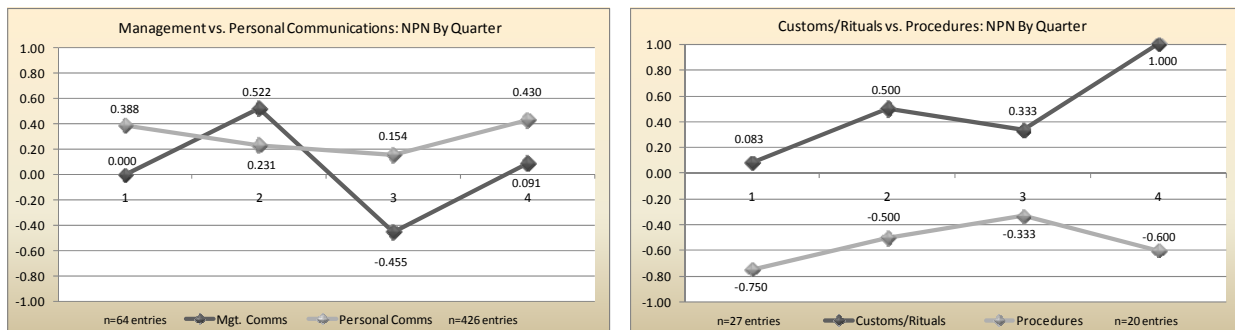
¹³ Journal entries complained about the condescending tone of some ground personnel when explaining a procedure or answering a technical question. Most ground control personnel routinely perform their jobs with skill, sensitivity, and devotion to the program. The astronauts rely on these people and sincerely appreciate their efforts.

¹⁴ “Stress” is used in this context to refer to the effects of specific and general stressors to which ISS crew are exposed. These include microgravity, separation from friends and family, schedule pressure, personal and external expectations, and constrained choices, among others.

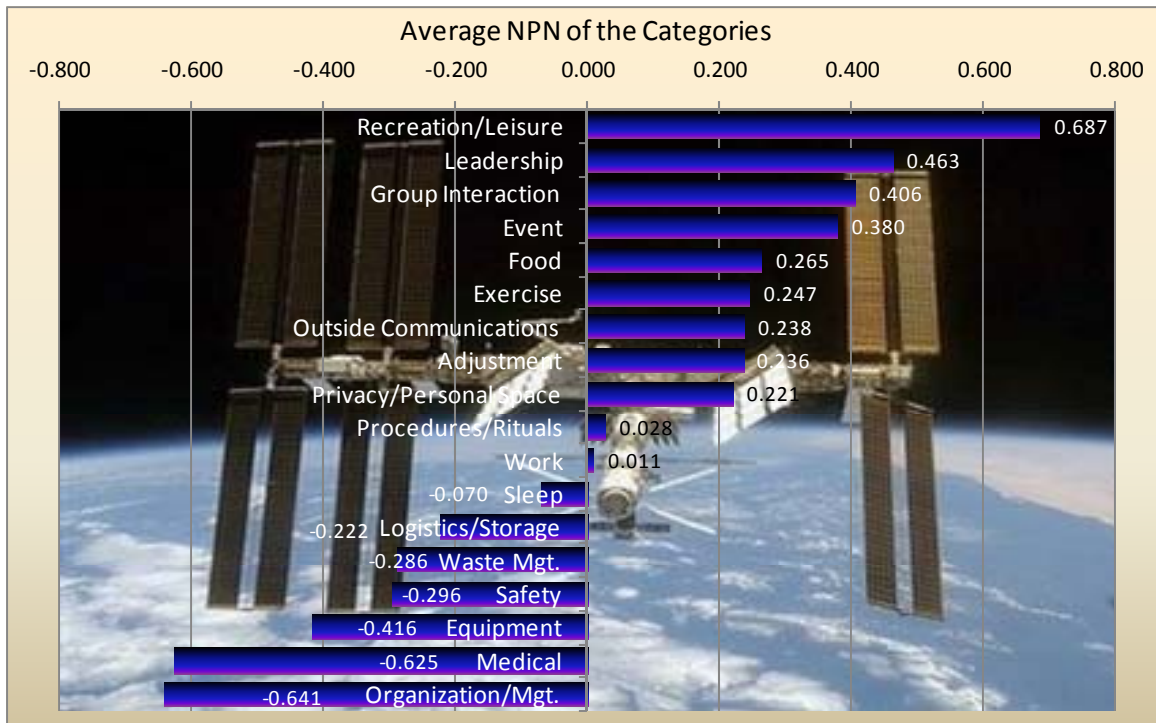
¹⁵ The examples of emergent psychosis among polar explorers represent the extreme of this response, but even less seriously disturbed individuals can threaten mission success.

IMPLICATIONS OF THE NET POSITIVITY/NEGATIVITY ANALYSIS

The Net Positivity/Negativity analysis found substantial evidence of a third quarter phenomenon. Overall, NPN declined in the third quarter for only eight of the 18 categories of behavioral issues that were analyzed, but two of the top three categories were among the eight (Work and Adjustment), which contributed to a third quarter decline when data from all categories were combined. Six of the 10 astronaut journals showed a decline during the third quarter on the combined measure and nine out of 10 in entries assigned to Adjustment, the category that most closely reflects individual morale. In addition, comparisons of subsets found third quarter declines in NPN for all three pairs (Commanders vs. Flight Engineers, Men vs. Women, and Two-Person vs. Multi-Person Crews). Two comparisons of subcategories within a major category also were performed: 1) On average, communications concerning management and personal communications both declined during the third period, with the dip more pronounced for the management subcategory; and 2) Entries concerning customs and rituals declined during the third quarter, but remained positive during all four quarters, compared to entries about procedures which increased in NPN during the third quarter and remained negative during all four quarters. The results of these analyses are illustrated in the following figures.



An overall measure of NPN was calculated for the top 18 major categories, which found entries concerning recreation and leisure to be the most positive in tone and entries about organization and management to be the most negative, as illustrated in the following figure.



IMPLICATIONS OF THE QUESTIONNAIRE RESULTS

The primary implication of the questionnaire results is that life onboard the ISS is not as difficult as the astronauts expect it will be prior to launch. Overall, mid-expedition responses to the five questions were 24 percent lower than the pre-launch values and post-expedition responses were 25 percent lower. The physical demands appear to be progressively easier for the astronauts to handle as they gradually adapt to the conditions. Mental difficulty and the numbers of equipment and organizational problems remained about the same during the second halves of the expeditions as they were during the first halves. The numbers of interpersonal problems increased by an average of 20 percent during the second halves, but did not reach pre-launch expectations. However, it is important to note that the astronauts' estimates of interpersonal problems were the lowest of the five measures.

RECOMMENDATIONS

The 10 personal journals that are the subject of this study provide a detailed record of five person-years of living and working in space. Many recommendations can be derived from the nearly 300,000 words written by the astronauts about their experiences onboard the ISS. Those sufficiently interested in the topic to have read the Results section of this report probably have identified several actions that would improve adjustment to long-duration isolation and confinement. The following list presents only the most salient items to emerge from the analysis. Some of the recommendations would involve additional work by astronauts to implement and others would require additional effort by ground control, mission planning, and/or management personnel. Some of the items might already have been implemented.

- Distribute tedious and housekeeping tasks as evenly as possible among the crew.
- Design tasks to have tangible results, to the extent possible. Encourage astronauts and investigators to collaborate on biological and physical science experiments.
- Schedule sufficient time for the performance of all tasks. Include time to locate and assemble tools, materials, and procedures needed, and time to set-up, perform the task, and return all items to their previous locations. Allocate additional time in the schedule when in doubt of the requirements. Assign former ISS crew personnel to review schedules to ensure that sufficient time has been allocated to complete all task elements under operational conditions.
- Note all errors (and deficiencies) in procedures as they are discovered during operations and correct the document within 24 hours if the procedure is expected to be used at any time in the future. This will avoid subjecting another astronaut, or the same one again, to the problem. Do not delay correcting procedures until it might be convenient to do so, because it probably never will be. Assign former ISS crew personnel to review the modifications.
- Assign former ISS crew personnel to review new procedures to ensure that the words used to describe on-orbit items match the words used in ISS documentation and labels.
- Allow ISS astronauts to control their individual schedules as much as possible.
- Involve crew personnel in discussions of all issues that might affect them, even relatively minor issues. Individuals may choose to decline, but it is important to ask.
- Schedule ISS crews to meet with the PAYCOM and MCC personnel with whom they later will be working as part of standard, pre-expedition preparations.
- Revive the Expedition Corps Training Program that was developed by the Astronaut Office in 1999 and include the two-day seminar in pre-expedition training. Add sessions about specific topics necessary for adapting to ISS conditions with the assistance of former ISS crew personnel and flight surgeons (e.g., how to obtain sufficient sleep, methods for expressing concerns, useful coping behaviors).

- Provide in-service training to MCC and PAYCOM personnel to increase understanding of the behavioral issues associated with isolation and confinement. This could be as brief as a two-hour session based on the Expedition Corps seminar, augmented by study results and recent operational experience.¹⁶
- Enable the Psychological Support Office to expand delivery of the types of services already provided to ISS astronauts and their families, which are among the most important contributors to successful adjustment, according to the current study (e.g., crew discretionary events, family teleconferences, IP phone).
- Be especially careful about the food (to paraphrase Fridtjof Nansen's famous advice); that is, ensure individual requests are satisfied and that packages are labeled accurately. Include surprises in some containers in addition to the items indicated on a label; an unexpected treat contributes to morale among remote duty personnel when found (e.g., special food, extra tortillas, a note) and is a tradition of expedition outfitters.
- Include food items that can be assembled to create special meals to be shared by a crew.
- Maintain sufficient backup supplies to ensure that normal quantities of food and other consumable items are available during contingency operations (i.e., eight months without the possibility of resupply). Distribute storage to avoid loss of all food in a single event.
- Expect third quarters of expeditions to be especially difficult for remote duty personnel. Schedule more crew discretionary events (CDEs) and meaningful or novel tasks during these periods.¹⁷
- Continue the Journals Flight Experiment.

The final recommendation is more than the usual pitch by an investigator to conduct additional research. Conditions changed on the ISS during the study period and subsequently: STS resumed, equipment and modules were added, operations benefitted from experience, and crew size, multinational composition, and the numbers of visitors increased. The doubling of crew size, in particular, has altered the conditions onboard the ISS since most of the journals were written. For these reasons, it is now appropriate to study the effects of these changes on the behavioral issues. However, an equally compelling reason for continuing the journals flight experiment is that it serves as an outlet for frustration that if expressed directly could damage relationships. Study participants recognized this unintended benefit of the experience, as illustrated by the following entries and public statements.¹⁸

I feel like I am complaining in these journals, and maybe that is what they are for.

I often I use this journal to vent my frustrations. This helps me collect my composure to deal with the situations. I must continue to look at the big picture and count myself lucky to be here.

I think it is good to write this down—typing gets out some of these frustrations.

Writing in this journal helps to let off steam!

So that was fun. Today's log was intended as an outlet for myself to just vent, and have some fun with the things that I notice that are not perfect.

I used it almost as a therapy for myself; if I were upset about something or frustrated, I'd write about it. Sometimes those entries were long.

Writing in my journal helped me keep proper perspective on events. It alerted me to when I was becoming too negative about something and reminded me of the things I enjoy about my job.

¹⁶ This recommendation was suggested by a highly-experienced payload communicator.

¹⁷ Most of the journal entries concerning CDEs were written during the second and fourth quarters of expeditions. It is unknown whether the number of reported CDEs during third quarters reflects depressed affect or fewer events.

¹⁸ The only regrets expressed by participants concerning the study were that they wished they had written more frequently in their journals.

Continuing the journals experiment to provide an outlet for crew frustration, in addition to collecting data, is not a substitute for the psychological support services and medical consultations provided by NASA. However, there are institutional obstacles that occasionally prevent astronauts from communicating candidly with individuals in the organization, including their personal physicians; the relationship between operators and flight surgeons always is tempered by the physician's authority to disqualify his or her patient from flight opportunities. Several journal entries describe astronauts' reluctance to confide in anyone about certain matters. Mostly when astronauts refrained from speaking candidly during private conferences with medical or management personnel it was to avoid being perceived as difficult or a complainer, but they wrote about the issues that bothered them in their journals and felt better afterwards.

The astronauts who benefitted in this manner might have experienced similar effects if their journals had remained unread by anyone else, but I doubt it. Rather, I believe the astronauts made regular journal entries and wrote honestly about their experiences because it was, 1) science (i.e., meaningful work); 2) an opportunity to contribute to improving conditions for future space crews; and 3) a reason to produce the written record they wanted to help recall events later (i.e., tangible results for their effort). The cathartic effects described by the astronauts seem to have been unexpected, but were derived primarily from knowing that someone outside the organization would read the entries sympathetically. They did not simply "let off steam," they conveyed their frustrations to another human being. It is a relatively safe and effective coping mechanism that also happens to generate large volumes of behavioral data.

CONCLUSIONS

This study has provided the first quantitative data from space operations on which to base a rank-ordering of behavioral issues. The first level of analysis identified the relative salience of 24 major categories of issues among which the top 10 accounted for 88 percent of all category assignments: Work, Outside Communications, Adjustment, Group Interaction, Recreation/Leisure, Equipment, Events, Organization/Management, Sleep, and Food. The second-level of analysis identified subcategories within the major categories and calculated their temporal distributions. The third level of analysis focused on the tone of entries as an indicator of specific problems and general morale; results of the NPN analysis support hypotheses concerning a third quarter phenomenon. The operational implications of these and other study results were assembled in the form of recommendations to facilitate living and working in space, whether onboard the ISS, a spacecraft bound for an asteroid, or an interplanetary ship.

Much has been written about the personal qualities of astronauts—achievement-oriented, competitive, analytical, etc. There probably is substance to at least some of the generalizations, as well as considerable individual variation within the Astronaut Corps. However, the most salient personal quality evident from my interactions with astronauts during this study is that they share an unusually well-developed sense of self-awareness. I had been led to believe that astronauts tended to be overly confident and certainly unwilling to admit to possessing flaws or normal human frailties. I am sure that some astronauts are afflicted with these traits, but those participating in this study demonstrated keen awareness of their capabilities and limitations, a personal quality that further distinguishes them from nearly everyone else.

The astronauts wrote candidly and insightfully about their experiences with the hope that their journals would be used to improve conditions for subsequent ISS crews and the crews of future space expeditions. I have done my best to mask the identity of participants in the study and to prevent the attribution of entries to specific individuals. However, the astronauts whose journals are examined here deserve recognition for the discipline they exhibited by maintaining continuous records of their expeditions and the courage necessary to write candidly.

FINAL NOTE

In the first days of the year 2001, the crew of ISS Expedition 1, Commander William Shepherd and Flight Engineers Yuri Gidzenko and Sergei Krikalev, watched the 1968 movie, *2001: A Space Odyssey* and the 1984 sequel *2010*—the latter describing a joint American-Soviet mission to Jupiter. The irony of former cold war adversaries living and working harmoniously in space was not lost on Bill Shepherd, who had spent most of his naval career preparing for war with the Soviet Union. He also felt strange watching a movie about a space expedition while he was on one, the same feeling expressed by several participants in the current study. Captain Shepherd wrote his final entry in the station log two months later:

Change of command is an ancient naval tradition — the passage of responsibility for mission, welfare of crew, and integrity of vessel from one individual to another. We are on a true space ship now, making her way above any Earthly boundary. We are not the first crew to board Alpha, or the last to depart. But we have made Alpha come alive. We gave her a name and put substance to the ideas — that our crews can work together as equals and our countries as partners. We pass to your care Alpha's log, with the hope that many successful entries are recorded here, that explorations carried out onboard are prodigious, and discoveries wondrous. May the good will, spirit, and sense of mission we have enjoyed onboard endure. Sail her well.



APPENDIX A

NOTE CONCERNING THE 1961 NORTH AMERICAN AVIATION SIMULATION

Donald Brown is Professor Emeritus in the Department of Anthropology at the University of California, Santa Barbara; he is an expert in the peoples and cultures of Borneo and author of *Human Universals*, which is among the finest examples of synthesis in the behavioral sciences. While a student at UCLA in 1961, he volunteered to serve as a subject in a 12-day simulation conducted by North American Aviation to help identify life sciences requirements for the Apollo Program. Dr. Brown provided the image that appears below the list of figures in the table of contents on page iv of this report (he is on the right) and the following description of his participation nearly 50 years ago in one of the little-known studies that contributed to the human presence in space. Information about the investigator is presented after Don's delightful description of the experiment.

The thinking behind that experiment that I was aware of was the assumption that basically space flight would be boring and repetitive but that when action might be required responses might need to be very fast and accurate. So we were given a boring but demanding task to perform. The panel in front of us went right to the limits of our vision, so you had to keep your eyes straight ahead. The flashing of a light was a rare event but you had to be continuously vigilant, as the time that elapsed after a light went on and you correctly responded determined the pay.

We took our blood pressure, pulse, and heart rate periodically while we were not at the task. These were recorded in a journal. I do not recall whether we were invited or requested to write more in the journals.

One guy found it so frustrating that he opted out after about a week. He then sat around for the remainder of the time. We all got along well with each other. They were med students and I was the technician.

We were on duty for 2 hours then off for 4, round the clock. There were two bunk beds, each with a red blanket. The turnover of air in the capsule was so vigorous that the blankets substantially disintegrated over the two weeks.

At one end of the capsule was a curtained-off john. It had a freezer of food in it, and as we removed food we inserted our feces in plastic bags. In the end there was a bit of panic as the doctor wanted to analyze the feces but no one had thought to ask us to identify whose were whose. As it turned out, we had all used different knots, so sorting them out was not a problem.

We were observed through one-way windows and I presume the psychologists were making various observations and probably had some sort of experimentation going on. We had all been psychologically and medically examined before the experiment.

One technical problem developed in the course of the experiment. It was a loose wire that I could have fixed in 2 minutes, but the people outside wanted to discover remotely what it was and try to fix it themselves. They did ultimately determine the problem but then I fixed it.

Each of us had been allowed to bring a cubic foot of personal items into the capsule. I forget what all was disallowed. I think mostly we just took reading material.

The principal figure in charge was [flight surgeon, Dr. Toby Freedman] from the med school at UCLA. He is mentioned in *Angle of Attack*, but I have never looked for his publications to see if he might have written something about the experiment. It surely must be the case though that the experiment was described in NAA's proposal to NASA.¹⁹

¹⁹ Gray, M. *Angle of Attack: Harrison Storms and the Race to the Moon*. New York: Penguin Book, 1992. This thoroughly-researched and engaging account of the most challenging technology project of the Twentieth Century should be required reading for everyone involved in the human exploration of space. The author dedicated the book to "the 400,000 men and women who built the first spaceship from Planet Earth and to the American people who picked up the tab." Mike Gray also wrote *The China Syndrome*.

Dr. Toby Freedman

Toby Freedman was an Air Force flight surgeon during the Korean War and in 1954 was part of a team that treated the test pilot who had barely survived the first ejection at supersonic speed, which led him into the new area of aerospace medicine. He was hired by North American Aviation to assist on the X-15 project and when Harrison Storms received authorization to bid on the Apollo program, he brought Freedman to the aircraft plant in Downey, California, to handle the life sciences section of the proposal. Space life sciences had to be invented as they went along, as there was no previous experience in the effects of spaceflight on humans. Toby Freedman's simulation experiment, conducted in a partitioned area of the factory's old cafeteria, led to several insights that were, indeed, incorporated in North American's proposal. No one expected the company to win the contract, but NASA was impressed by the proposal's attention to detail, which included preliminary data concerning human performance in isolation and confinement.

Dr. Freedman continued to lead human factors engineering for North American (later known as North American Rockwell and then Rockwell International), and served as personal physician to the senior engineering managers, several of whom he nursed through heart attacks brought on by the stress of meeting the goal of landing astronauts on the Moon within the decade.



APPENDIX B

THE THIRD QUARTER PHENOMENON

The term, “Third Quarter Phenomenon,” was coined by Robert Bechtel to describe a characteristic of finite-time stressful situations that he identified primarily from anecdotal accounts collected during a study of life in cold regions (Bechtel and Berning, 1991). Bechtel found that the incidence of accidents, assaults, and requests for marital counseling peaked after the worst of the winter conditions had passed, rather than at the mid-point, as might be expected. He then read about the interviews of Antarctic winter-over personnel conducted by John Rohrer in 1958 as part of the International Geophysical Year (IGY) science program; those interviews led Rohrer to identify three stages of reaction to long-duration isolation: An initial stage of heightened anxiety; a second stage of settling into a routine, which is accompanied by depression; and a third stage of anticipation, which is characterized by emotional outbursts and aggressiveness (Rohrer, 1961). Rohrer observed that the sequence of stages remained the same regardless of the length of the mission. Bechtel also found a paper about adjustment to life onboard early Polaris nuclear submarines by psychiatrist, Jim Earls, which described a seven-stage response that included a “half way syndrome” characterized by depression; however, the data show the response occurring well after the half-way points of the missions, that is, during the third quarters. Earls cited depression as the most common response to long-duration submarine patrols and described the pattern clearly:

The crux of the various forces leading to this depressive position would appear to be the anger experienced by the various members of the crew. The anger is an outgrowth of the frustrations experienced by the submariner in dealing with his environment. However, there appears to be no personally or culturally acceptable means of discharging this anger. The paternalistic organization of the military system is one which does not permit the direct expression of anger and aggression toward the military system. In addition, there is the personal fear that the overt expression of anger may lead to a socially isolated position within an already isolated community. The individual has little opportunity to handle his hostile affect by sublimation, except through humor. The submariner is then forced to deal with his anger by denial, suppression, or turning against himself. The hostile affect becomes internalized, but it ultimately manifests itself as a depressive phenomenon. (Earls, 1969, p. 122)

Eric Gunderson and Paul Nelson reported sleeplessness, depression, irritability, and anxiety after the mid-winter period among 90 US Antarctic winter-over personnel (1963), which does not allow attribution to the third quarter, but is suggestive, as is the reference to “drifting behavior” as a late winter phenomenon by Popkin et al. (1974).

It was mentioned previously that the French Diaries study found evidence of a third quarter phenomenon across broad ranges of expedition durations and crew sizes (Stuster, Bachelard, and Suedfeld, 1999, 2000). Further, Marilyn Dudley Rowley and her associates reported evidence for a third-quarter phenomenon in the form of increased rates of deviance and conflict during polar and space expeditions (2000). G. Daniel Steel found moderate empirical support for a third-quarter phenomenon at a New Zealand Antarctic base using mood scales, with certain dimensions more susceptible to temporal effects than others (Steel, 2001). And, Greg Décamps and Elisabeth Rosnet reported third-quarter phenomena among 27 personnel of the French Dumont d’Urville Antarctic station, based on observations made by the expedition physician during a 50-week period (Décamps and Rosnet, 2005).

Nick Kanas and his international team of investigators found no evidence of a third quarter effect on any of the 21 subscales used in the Interactions Study to assess mood among US and Russian crew members during nine expeditions on Mir and the ISS (2006). However, the study discovered strong evidence to support displacement of tension and negative emotions from crewmembers to mission control personnel and from mission control personnel to management.

Psychiatric interpretation is beyond the scope of this study, which is concerned primarily with the behavioral outcomes of physical and cognitive processes. However, an exception must be made for “displacement,” which is the shifting of actions or feelings from one entity to a substitute when there are obstacles to the original object; it is probably the most widely understood psychiatric concept. The cliché example is, “The boss shouts at me. I go home and shout at my wife. She shouts at our child. With no one remaining, the child kicks the dog.” This common coping behavior might explain some of the negativity in the journal entries concerning ground control and management personnel.

REFERENCES

- Bechtel, R. and Berning, A. The Third Quarter Phenomenon: Do People Experience Discomfort After Stress Has Passed? In, *From Antarctica to Outer Space: Life In Isolation and Confinement*. A. Harrison, Y. Clearwater, and C. McKay, Eds. New York: Springer-Verlag, 1991.
- Décamps, G. and Rosnet, E. A Longitudinal Assessment of Psychological Adaptation During a Winter-Over in Antarctica, *Environment and Behavior*, 37: 3, 418-435, 2005.
- Earls, J.H. Human Adjustment to an Exotic Environment: The Nuclear Submarine. *Archives of General Psychiatry* 20:117-123, 1969.
- Gunderson, E.K.E. and Nelson, P.D. Adaptation of Small Groups to Extreme Environments. *Aerospace Medicine* 34, 1111-1115, 1963.
- Kanas, N.A., V.P. Salnitskiy, J.B. Ritscher, V.I. Gushin, D.S. Weiss, S.A. Saylor, O.P. Kozerenko and C.R. Marmar. Human Interactions in Space: ISS vs. Shuttle/Mir. *Acta Astronautica* 59: 1-5, 413-419, July-September 2006.
- Popkin, M., Stillner, V., Osborn, L., Pierce, C., and Shurley, J. Novel Behaviors in an Extreme Environment. *American Journal of Psychiatry* 131, 651-654, 1974.
- Rohrer, J. Interpersonal Relationships in Small Isolated Groups. In, *Psychophysiological Aspects of Space Flight*, B.E. Flaherty, Ed. New York: Columbia University Press, 1961.
- Rowley, M., Nolan, P., Bishop, S., Farry, K., and Gangale, T. Crew Composition, Time, and Subjective Experience in Mars-Analog Expeditions. Paper presented at the Third International Convention of the Mars Society, Toronto, Ontario, August 2000.
- Steel, G.D. Polar Moods: Third Quarter Phenomena in the Antarctic. *Environment and Behavior*, 33: 1, 126-133, 2001.
- Stuster, J., Bachelard, C. and Suedfeld, P. *In the Wake of the Astrolabe: Review and Analysis of Diaries Maintained by the Leaders and Physicians at French Remote Duty Stations*. Technical Report to the National Aeronautics and Space Administration, 1999 (February).
- Stuster, J., Bachelard, C. and Suedfeld, P. The Relative Importance of Behavioral Issues During Long-Duration I.C.E. Missions. *Aviation, Space, and Environmental Medicine* 71 9, 2000 (September).

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